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ABSTRACT

Designed to assist instructors in preparing secondary and adult students for employment in the field of fuel system services, this guide outlines eight units of instruction. The eight unit titles are (1) Introduction (overview of course content and requirements, and work/safety habits), (2) Minor Components, (3) Carburetor Fundamentals, (4) Automotive Carburetors, (5) Carburetor Diagnosis and Overhaul, (6) Automotive Fuels, (7) Automotive Emission Control Systems, and (8) Fuel Injection, Superchargers, and Liquefied Petroleum Gas Systems. Methods and materials are suggested for enriching the course and achieving a more effective presentation. A two-column format is used: the left-hand column contains suggested topics which are keyed to specific objectives; the right-hand column gives related factual information, as well as instructional suggestions and page references for selected textbooks. At the conclusion of each unit, topics for review discussion are included. A sample final examination is also provided. A list of suggested aids is given in the bibliography: Textbooks, reference books, booklets and charts, films, filmstrips, slides, film loops, and transparencies. (HD)

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Automotive Industries Occupations

AN INSTRUCTOR'S GUIDE FOR A PROGRAM IN

FUEL SYSTEM SERVICES

TRADE AND TECHNICAL EDUCATION

U S DEPARTMENT OF HEALTH EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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BUREAU OF CONTINUING EDUCATION CURRICULUM DEVELOPMENT
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Foreword

Fuel System Services was developed from the suggested services for the automotive fuel system that are listed in the *Automotive Service Occupations*. The content may be used in secondary schools and adult programs to assist in preparing individuals who wish to enter the automotive field or to upgrade personnel already working as automotive mechanics.

Appreciation is expressed to Wallace Chapman, auto mechanics instructor at Hudson Valley Community College, Troy, for his efforts in developing the instructional materials. Assistance relating to content was provided by Clyde C. Tiffany, Jr., associate in the Bureau of Trade and Technical Education. The project was coordinated and the manuscript edited and prepared for publication by Nelson S. Maurer, associate in the Bureau of Continuing Education Curriculum Development.

HERBERT BOTHAMLEY, *Chief*
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Message to the Instructor

Fuel System Services is designed to prepare students for employment in the specialized area of automotive service. Units are presented in numerical order, but the sequence may be altered to accommodate the needs and backgrounds of the trainees. The availability of tools and equipment also may necessitate adaptations in the use of the materials. Advanced information not required in a general automotive program is marked with an asterisk (*) and may be omitted from the basic course if the time is limited.

This guide suggests methods and materials that should enrich a course and help achieve a more effective presentation. The general objectives for each unit are stated in terms of behavioral activities that the student is able to do as a result of the instruction. The standards, as determined by the instructor, should be the minimum acceptable proficiency necessary for an entry mechanic in the area of fuel system service. More detailed objectives may be developed, if desired, and these also should be stated as observable behavior that the learner is able to do when applying the skills and knowledges acquired. The left-hand column gives related factual information, as well as suggested teaching techniques and page references for selected textbooks. At the conclusion of each unit, topics for review are included. Also, a sample final examination is provided.

The use of instructional aids will greatly clarify the presentation of the material. A list of suggested aids appears at the end of each unit. Excellent instructional materials are available from various automobile and automotive equipment manufacturers. Local dealers will often donate service instructional materials after they have presented the information to their own mechanics. Specific items may be located in *Automotive Instructional Material* published by the Automotive Service Industry Association. Many useful teaching aids are easily fabricated from samples or discarded equipment.

New instructional aids are constantly being made available to instructors. Current releases of audiovisual aids are usually listed in issues of such publications as *American Vocational Journal*, *Industrial Arts and Vocational Education*, and *School Shop*. New information relating to the automotive industry is available from automotive trade magazines and automotive enthusiasts publications.

CARL G. BENENATI, *Chief*
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UNIT 1

Introduction

OBJECTIVES

The student will be able:

- To assess the value of the course in meeting his perceived occupational needs
- To demonstrate appropriate work habits and attitudes during training and on the job
- To explain the functions and relationships of the fuel and ignition systems to the operation of the internal combustion engine
- To identify and explain the operation of the component parts of a fuel system
- To list the fundamental circuits of a carburetor

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Importance of Servicing the Fuel System	With the increased emphasis on ecology and the need for cleaner air, all sources of air pollution have come under careful study. In many areas, the automobile has proved to be one of the major sources of air pollution. Laws have been enacted, and the automotive manufacturers have engineered many changes which have dramatically reduced harmful emissions. To keep pollution at these low levels, it is necessary that the various systems of the vehicle be carefully serviced at regular intervals. The fuel and air pollution control systems need periodic maintenance to keep them working as designed. In order to perform this service, many mechanics will need additional training to develop new skills. The purposes of the course are: • To permit individuals who are now working as automotive mechanics to upgrade and update their knowledge in the rapidly changing area of fuel system service

Introduction

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• To provide training in fuel system service for students in BOCES and occupational education programs and other interested persons
II. Overview of Course	*Discuss the general subject matter that is to be covered in each unit of the course. Also, indicate such items as the length of each session, the number of sessions, the procedures to be followed in class, the reasons for homework, and in general, the expectations for each class member.* *Emphasize that there will be quizzes throughout the course and an examination at the end. Note that following the final examination, time will be allotted for a review of the test and for answering questions about the course.*
A. Individual needs	*Determine the background and needs of each student, and use this information to adjust the course content as closely as possible with the equipment available.* *Develop a card data file for each student, listing address, phone number, needs, goals, training, work experience, and other pertinent information. This file will be valuable in giving individual aid during the course. It will also help maintain contact with students after employment. Former students can always help to provide up-to-date trade information and training aids as well as placement assistance.*
B. Work habits and attitudes	*Discuss the importance of good work habits and show how these might aid an individual in maintaining and improving his position. Include such items as:* • *Sense of responsibility to employer and other employees* • *Appreciation of safety rules and regulations* • *Accuracy and speed* *Discuss the attitudes that employers like to find in employees.* *Indicate that many times the cause for a worker's dismissal is related to his poor work habits and not to his lack of knowledge.*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Emphasize the importance of developing good work habits and desirable attitudes during the course. (Ref. What employers want; why young people fail to get and hold jobs.)
III. Course Requirements	
A. Prerequisites	It would be advantageous for students to be knowledgeable in the following areas: • Basic mathematics • Basic science • Principles of operation of the internal combustion engine • Basic principles of ignition systems • Shop safety
B. Textbook	*If a textbook is to be used, give its title, price, and source. Arrange for a group order.†*
C. Notebook	*Indicate that a looseleaf notebook is necessary for keeping class notes, job information, specification booklets, and other materials distributed during the course.*
IV. General Safety	*Review general rules of safety for the service garage employee. (Ref. C, pp. 11-32; Ref. F, pp. 195-197; General safety instructions; Safety in your future; Your guide to safety as a service garage employee)* *Show a safety film or use (humorous) safety transparencies to introduce the topic. Ask students to discuss their own experiences with accidents and ask them to indicate the safety procedures that should have been followed.* *Discuss the dangers of horseplay and hot rodding, and give examples of the possible consequences of each.* *Show the location of fire extinguishers and discuss fire control procedures.*

†Textbook citations are given at the end of each unit.

Introduction

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Discuss the specific safety procedures for using the following: • *Gasoline* • *Carburetor cleaner* • *Compressed air*
A. Protective clothing	*State school policy relative to coveralls, shop coats, or uniforms. Mention possible storage areas for clothes.*
B. Safety glasses	*Indicate the school policy relative to the wearing of approved safety glasses.* *Arrange for a group purchase of approved safety glasses for those who wish to have their own glasses.*
V. Internal Combustion Engine Operation	*Review the basic operation of the internal combustion engine. Discuss such items as:* • *Four-stroke cycle — intake, compression, power, and exhaust* • *Two-stroke cycle** *Explain the relationship of ignition and carburetion to engine operation. (Ref. A, pp. 8-9; 15-19; Ref. B, pp. 61-63; Ref. D, pp. 13-15)*
VI. Fuel System	
A. Components	*Demonstrate and explain briefly the functions of the components of a fuel system. Include such items as:* • *Gas cap* • *Fuel tank* • *Fuel lines* • *Fuel pump* • *Fuel filters* • *Air cleaners* • *Carburetors* • *Intake manifold* • *Exhaust manifold* • *Exhaust pipe* • *Muffler and tail pipe* • *Emission control devices*

*Important for an advanced course; may be omitted from a basic course.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Most American-made fuel pumps are now sealed at the factory and cannot be disassembled. Older American-made and many foreign-made fuel pumps may be taken apart for inspection. (Ref. A, p. 22; Ref. C, p. 150; Ref. F, p. 255)
	Electric pumps are now standard equipment on some American-made passenger cars. (Ref. A, pp. 40-42; Ref. F, pp. 257-259; Ref. G, p. 317)
B. Operation	*Demonstrate the operation of the automotive fuel system. Discuss the following terms as they relate to carburetion and illustrate with familiar examples:* • *Evaporation — liquid to gas* • *Gravity — liquid level and vehicle position* • *Inertia — liquid level and vehicle movement* • *Pressure — fuel movement* *Atmospheric — normal* *Vacuum — difference in pressure* *Venturi action — Bernoulli's principle* *Absolute — in inches of mercury** • *Atomization — spray gun* (Ref. A, pp. 25-29, 50-53; Ref. C, pp. 150-151; Ref. F, pp. 206-207)
VII. Carburetor Circuits	*Discuss the function and operation of the following carburetor circuits:* • *Float* • *Choke* • *Idle* • *Low speed (off idle or intermediate)*☆ • *Main (high speed or cruise)*☆ • *Power (high speed full load or full throttle)*☆ • *Acceleration (pump)*☆

☆Common trade terms are used throughout this guide. Since there is no common agreement on these terms, the first term will have the same meaning as the terms in the parenthesis.

Introduction

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, pp. 65-81; Ref. C, pp. 151-156; Ref. G, pp. 320-328)
	Demonstrate the effects of manifold vacuum and atmospheric pressure by connecting a gallon can to the intake manifold of an operating engine. Atmosphere pressure causes the can to collapse.
	Use films, transparencies, and charts to assist in presenting the fundamentals of a fuel system.

TOPICS FOR REVIEW

1. List in order the strokes of the four-stroke cycle engine, and explain their relationship to carburetion.
2. Name the components of a fuel system.
3. Define vacuum, difference in pressure, and atmospheric pressure. Tell how they are used in the study of carburetion.
4. Describe Bernoulli's principle (venturi action), and tell why it is important in carburetion.
5. Explain how the carburetor uses heat and atomization to improve the fuel mixture.
6. Explain why the rebuilding of some fuel pumps is impossible.
7. Explain the function of a fuel system.
8. Why does a six cylinder manifold often cause an unequal distribution of fuel?
9. Why is it better to think of a difference in pressure between two points than of a vacuum at one point?
10. Draw a fuel system and label all component parts.

INSTRUCTIONAL MATERIALS

TEXTBOOKS

(A) Crouse, W. H. *Automotive fuel, lubricating, and cooling systems;* 4th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1971.

(B) _____ *Automotive mechanics;* 6th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1970.

(C) Glenn, H. T. *Automechanics;* 2d ed. Peoria, Ill. Chas. A. Bennett Co., Inc. 1969.

(D) Stockel, M. W. *Auto mechanics fundamentals.* Homewood, Ill. Goodheart-Willcox Co., Inc. 1969.

(E) _____ *Auto services and repair.* Homewood, Ill. Goodheart-Willcox Co., Inc. 1969.

(F) Toboldt, W. K. & Johnson, Larry. *Motor service's automotive encyclopedia.* Homewood, Ill. Goodheart-Willcox Co., Inc. 1969.

(G) Wetzel, G. F. *Automotive diagnosis and tune-up.* Bloomington, Ill. McKnight & McKnight Publishing Co. 1969.

REFERENCE BOOKS

Deere and Company. *Fundamentals of service; fuels, lubricants, and coolants.* Moline, Ill. The Corporation. 1970.

PAMPHLETS AND CHARTS

American Insurance Association. *General safety instruction.* New York, N.Y. The Association. 1946.

_____ *Your guide to safety as a service garage employee.* New York, N.Y. The Association. 1956.

Ford Motor Co., Industrial Relations, Employee Programs. *General safe practices.* Dearborn, Mich. The Corporation. 1963.

General Motors Corporation, Public Relations Staff. *Fuel system chart.* Detroit, Mich. The Corporation.

Humble Oil and Refining Co. *How to work safely in a service station.* Houston, Texas. The Corporation. 1966.

New York State Department of Labor, Division of Employment. *Why young people fail to get and hold jobs.* Albany, N.Y. The Division. 1970.

Science Research Associates, Inc. *What employers want.* Chicago, Ill. The Corporation. 1950.

U.S. Department of Labor, Occupational, Safety, and Health Adm. *Safety in your future.* Washington, D.C. U.S. Government Printing Office. 1966.

FILMS

The ABC of hand tools. General Motors Corp. 1946. 33 min. sound. color. Loan — General Motors Corp.

The ABC of internal combustion. General Motors Corp. 1948. 13 min. sound. color. Loan — General Motors Corp.

Introduction

The ABC of the automobile engine. General Motors Corp. 1948. 18 min. sound. color. Loan — General Motors Corp.

Carburetor, principles of operation. Norwood. 25 min. black and white. Purchase — National Audiovisual Center.

The cooling system and fuel system. 22 min. Purchase — National Audiovisual Center.

Fire power. Ethyl Corp. 1971. 20 min. sound. color. Loan — Ethyl Corp.

Where mileage begins. General Motors Corp. 1961. 26 min. sound. color. Loan — General Motors Corp.

FILMSTRIPS

The fuel system. Scott Education Division. 1969. 48 frs. color. Purchase — Scott Education Division.

Fuel system, principles of operation. Ford Motor Co. 1964. 34 frs. sound. color. Purchase — Educational Affairs Dept., Ford Motor Co.

FILM LOOPS

The 4-cycle engine. 8½ min. color. sound. Purchase — Carousel Films, Inc.

The 2-cycle engine. Carousel. 4 min. color. sound. Purchase — Carousel Films, Inc.

TRANSPARENCIES

Auto testing - fuel system, tuning. 3M Co. 23 visuals. color. Purchase — 3M Co.

Auto testing - ignition system. 3M Co. 23 visuals. color. Purchase — 3M Co.

Auto testing - spark and ignition. 3M Co. 23 visuals. color. Purchase — 3M Co.

Engine and fuel systems. McGraw-Hill. Purchase — McGraw-Hill.

Fuel system. DCA Educational Products, Inc. Six transparencies. color. Purchase — DCA Educational Products, Inc.

Safety in the shops. 3M Co. 23 visuals. color. Purchase — 3M Co.

Minor Components

OBJECTIVES

The student will be able:

- To explain the operation of commonly used fuel pumps
- To diagnose and correct problems related to fuel lines, fuel pumps, fuel tanks, fuel filters, fuel gauges, air cleaners, and the exhaust system

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Fittings and Lines	*Discuss and show examples of the following fittings and fuel lines:* • *Pipe thread* • *Male and female fittings* • *Compression fittings* • *Flair fittings* • *Steel line* • *Copper line* • *Flex line* • *Neoprene line with clamps (Corbin)* "Natural rubber" lines should not be used as they swell and dissolve in gasoline. *Demonstrate the following operations that relate to fittings and fuel lires:* • *Bending tubing* • *Cutting tubing* • *Flairing tubing (also double flair)* • *Using flair nut wrench*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Starting fittings*
	(Ref. A, pp. 203-205)†
	Have students cut and flair tubing until each one can make a perfect flair. Students also should be able to identify the following:
	• *Pipe thread (type and size)*
	• *Line sizes*
	• *Male and female fittings (type and size)*
	• *Compression fittings*
	• *Flair fittings*
II. Fuel Pump	
A. Operation	The operation of the fuel pump should always be tested as part of a major tuneup.
	Discuss and demonstrate the operation of a single action fuel pump.
	Demonstrate the disassembly and reassembly of a fuel pump. Emphasize the importance of making index marks as a guide for reassembly. Point out the following parts:
	• *Inlet valve*
	• *Outlet valve*
	• *Diaphragm assembly*
	• *Diaphragm spring*
	• *Filter or screen*
	• *Rocker arm and lever assembly*
	• *Rocker arm and return spring*
	(Ref. A, pp. 209-215; Ref. E, pp. 20-7—20-13; Ref. F, pp. 255-259)
	Note: Use fuel pumps that are assembled with bolts.

†Textbook citations are given at the end of this unit.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Show examples of various electric pumps and explain briefly their operation.
	Have students disassemble and reassemble fuel pumps and identify the various parts.
	Mention the importance of inspecting a fuel pump carefully before disassembly to note the relationship of the various parts to each other.
	Emphasize the necessity of having a clean work space and of arranging the parts in an orderly fashion.
B. Malfunctions	*Discuss the following fuel pump malfunctions:*
	• *Cracked diaphragm*
	• *Broken rocker arm return spring*
	• *Defective valves — inlet, outlet*
	• *Defective diaphragm pull rod seal*
	(Ref. A, pp. 176-178; Ref. C, pp. 163-164)
	Demonstrate how to check for fuel pump malfunctions by using:
	• *Thumb for a simple bench check*
	• *Vacuum and pressure gauge to check pump operation and compare with manufacturer's specifications*
	• *Output capacity test*
	(Ref. C, p. 164)
	Keeping one pump operationally correct, ask the students to diagnose problems in several fuel pumps which the instructor has made defective. The malfunctions might include:
	• *Defective inlet valve*
	• *No return spring*
	• *Hole in diaphragm*
	• *Broken spring on outlet valve*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Be sure the fuel pump is actually at fault since many other problems may simulate a defective fuel pump. *Discuss problems that could simulate fuel pump troubles such as:* • *Plugged fuel tank filter* • *Clogged fuel line* • *Worn fuel pump lobe on camshaft* • *Restricted flex line* • *Vapor lock* *Indicate that a defective vacuum diaphragm on double diaphragm pumps could cause excessive oil consumption and simulate the need for new piston rings.*
C. Service	Most American-made fuel pumps are now sealed at the factory and cannot be repaired. Older American-made and many foreign-made fuel pumps may be disassembled for repairs. *Discuss and demonstrate the procedures for the replacement of a fuel pump and include the following:* • *Installing cam follower in correct position with extreme care* • *Using headless bolts or other aids to help proper assembly* • *Cementing gasket to pump to simplify installation* • *Using special tool for the push rod on a Chevrolet to ease installation* • *Tightening bolts evenly (do not overtighten)* (Ref. E, pp. 20-13—20-14) *Have students remove and replace fuel pumps on shop engines and live cars until they acquire the proficiency necessary for an entry mechanic.*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Discuss the use of special kits that are available for the repair of certain types of fuel pumps.
III. Fuel Tanks	*Discuss the procedures for the removal and replacement of fuel tanks. Emphasize the following:* • *Use penetrating oil or a nut buster to loosen rusty fittings* • *Store drained fuel in closed containers* *(Ref. E, pp. 20-2—20-3)* *Emphasize the necessity of using caution when draining fuel tanks because gasoline vapors are heavier than air and can travel along the floor and ignite with any spark or open flame.* *Discuss the procedures for repairing defective fuel tanks. Since this operation is hazardous and requires special equipment, it is recommended that fuel tanks needing repair be sent to a special repair shop.*
IV. Fuel Filters	*Discuss the different types of fuel filters including:* • *Ceramic* • *Porous bronze* • *Pleated paper* *(Ref. F, pp. 264-265)* *Discuss the functions and operation of fuel filters including the following locations:* • *Fuel tank* • *Fuel line* • *Fuel pump* • *Carburetor* *(Ref. A, p. 32; Ref. E, pp. 20-13—20-15)* *Demonstrate the procedures for servicing fuel filters.*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Discuss the care required to eliminate leaks when installing filters and gaskets. Emphasize that the improper servicing of a fuel system may create a fire hazard in the automobile.
V. Air Cleaners	Discuss the functions and operations of air cleaners. Include the following: • Oil wetted, copper mesh • Oil bath • Pleated paper • Polyurethane element (Ref. A, pp. 43-49; Ref. F, pp. 241-243)
	Demonstrate the procedures for servicing air cleaners.
	Have students perform fuel filter and air cleaner service jobs until they acquire the proficiency necessary for an entry mechanic. Include a wide variety of types of fuel filters and air cleaners.
	Always check the finished job for fuel leaks.
VI. Fuel Gauges	Discuss the functions and operations of various types of fuel gauges including: • Balancing coil gauge and resistance sending unit • Thermostatic gauge and sending unit • Thermostatic gauge and resistance sending unit • Instrument voltage regulator (Ford) (Ref. A, pp. 32-35; Ref. F, pp. 263-264)
	A useful training aid may be easily constructed by mounting several matching tank and dash units on plywood and wiring them so they may be operated by students.
	Demonstrate how to diagnose fuel gauge problems. Discuss the following:

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Jumper wire check*
	• *Extra tank unit used as transmitter*
	• *Danger of short circuits*
	• *Replacement of tank unit*
	• *Replacement of dash unit*
	Have students diagnose and correct fuel gauge problems by using the above mockup or live cars.
VII. Exhaust System	Since automobile exhaust contains carbon monoxide which is a deadly gas, exhaust system service must be done correctly to protect the driver and passengers.
A. Components	*Discuss the functions of the component parts of the exhaust system including:*
	• *Types of manifold gaskets*
	• *Exhaust pipes*
	• *Mufflers (straight through and by pass)*
	• *Tailpipes*
	• *Resonators*
	• *Hangers*
	• *Clamps*
B. Service	*Demonstrate the servicing of the component parts of the exhaust system including:*
	• *Removal*
	• *Replacement*
	• *Alinement*
	• *Repair*
	Have students practice exhaust system service on live cars. Emphasize safe use of the lift and care in positioning the exhaust system so that it does not contact brake lines or other parts that might be damaged.

Minor Components

TOPICS FOR REVIEW

1. Discuss the safety factors involved in servicing and repairing fuel tanks.

2. Describe the operation of an electric fuel gauge, and explain how to diagnose a defective system.

3. List four types of fuel filters, and describe the servicing of each.

4. List four types of air cleaners, and describe the servicing of each.

5. Why is safety so important on such simple units as the fuel filter or air cleaner?

6. Under what conditions might an oil bath air cleaner be recommended? Describe the servicing of this unit.

7. Give the procedure for freeing a steel fuel line fitting that is rusted to the fuel tank fitting.

8. Give several reasons for its being good business to include the installation of an in-line filter with a carburetor overhaul.

9. What is the reason for the voltage regulator in Ford's instrument system?

10. Draw a wiring diagram of an electric fuel gauge and sending unit. Label all parts and show all grounds.

11. Explain the operation of a single diaphragm fuel pump.

12. Explain fully how to diagnose a defective fuel pump with low pressure. List the equipment required to correct this problem.

13. Identify the following (from pictures or drawings): (a) a flair fitting (b) a male pipe thread fitting (c) a compression fitting (d) a flex line with male pipe fitting at one end and a female compression fitting at the other (e) a Corbin hose clamp.

14. Describe the removal and replacement of a fuel pump including the important safety precautions.

15. Discuss the advisability of rebuilding fuel pumps in a modern garage. Explain the cost and profit factors as well as the shop time involved.

16. Discuss vapor lock and explain ways the mechanic may reduce the problem.

17. How could the low output of a fuel pump which is caused by a worn fuel pump crankshaft lobe be economically corrected?

18. What might cause the crankcase oil level to register above normal and to smell of gasoline?

19. What results may be expected when the vacuum diaphragm of a double diaphragm pump leaks?

20. Explain why it is important to start fuel line fittings by hand.

INSTRUCTIONAL MATERIALS

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(B) _____ *Automotive mechanics;* 6th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1970.

(C) Glenn, H. T. *Automechanics;* 2d ed. Peoria, Ill. Chas. A. Bennett Co., Inc. 1969.

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(F) Toboldt, W. K. & Johnson, Larry. *Motor service's automotive encyclopedia.* Homewood, Ill. Goodheart-Willcox Co., Inc. 1969.

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_____ *Quality tune-up guidebook.* Flint, Mich. The Division. 1969.

FILMSTRIPS

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Fuel system, principles of operation. Ford Motor Co. 1964. 84 frs. sound. color. Purchase — Educational Affairs Dept., Ford Motor Co.

FILM LOOPS

Fuel pump. Sterling. 2½ min. Purchase — Sterling Educational Films.

Testing a fuel pump. Modern Learning Aids. 4 min. color. Purchase — Modern Learning Aids.

TRANSPARENCIES

Exhaust system. DCA. One transparency. color. Purchase — DCA Educational Products Inc.

Muffler replacement. DCA. One transparency. color. Purchase — DCA Educational Products Inc.

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Carburetor Fundamentals

OBJECTIVES

The student will be able:

- To explain the need for different air-fuel ratios for different vehicle speeds
- To identify carburetors by type and class
- To identify and explain the purpose and operation of the major parts and circuits of commonly used carburetors
- To disassemble and reassemble commonly used carburetors

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Purpose	*Explain that the purpose of the carburetor is to mix the fuel with air to obtain a combustible mixture of varying degrees of richness to satisfy different engine operating conditions.* (Ref. A, p. 60; Ref. B, pp. 6-7, 147-148; Ref. F, pp. 205-206)†
	Discuss air-fuel ratios, and explain the following mixtures:
	• *Normal* 14 to 1
	• *Lean* 16 to 1
	• *Power* 12 to 1
	• *Rich* 10 to 1
	(Ref. A, p. 60; Ref. B, pp. 150-151; Ref. D, p. 115)
	Draw on the chalkboard and explain the graph of air-fuel ratios for different vehicle speeds. (Ref. A, p. 60; Ref. B, p. 151)
	Demonstrate how different air-fuel ratios affect engine power by using a one cylinder engine

†Textbook citations are given at the end of this unit.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	attached to a small dynamometer (Go-Power) or a chassis dynamometer. (Ref. D, pp. 183-184)
II. Design	
A. Types	*Show examples and explain the advantages and disadvantages of the following types of carburetors:* • *Updraft (sometimes used with gravity feed)* • *Downdraft (practical on a V-8)* • *Sidedraft (sometimes used for low-hood line)* *(Ref. A, pp. 102-108)*
B. Classes	*Show examples and discuss the operation of the following classes of carburetors:* • *Single barrel (venturi)* • *Two barrel (venturi)* • *Four barrel (venturi)* • *Three barrel (Holley)** • *Four barrel inline (Autolite)** *(Ref. A, pp. 107-118; Ref. B, p. 165)* *Use filmstrips, films, and slides to assist in presenting the topic of carburetor types and classes. A few antique carburetors or slides of carburetors on antique automobiles might be helpful to highlight the changes that have been made in the development of the carburetor.*
III. Operation	
A. Venturi action	*Show examples and discuss the function and operation of the venturi in a carburetor. Since this is a difficult concept, use demonstrations, experiments, slides, films, filmstrips, and film loops to assist in the presentation.* *Discuss the following items related to venturi action:*

*Important for an advanced course; may be omitted from a basic course.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Boost venturi* • *Bowl vents* • *Inside vent (balanced carburetor)* • *Outside vent (results of a plugged vent or restricted air cleaner)* *(Ref. A, pp. 51-54, 61-65; Ref. D, pp. 124-126)*
B. Main discharge nozzle and main jet	*Show examples and discuss the functions and operations of the main discharge nozzle and main jet. Use the chalkboard, filmstrips, cutaway carburetors, and other visual aids to clarify the following points:* • *Location of main discharge nozzle in venturi* • *Importance of float level in relation to main discharge nozzle* • *Effect of motion of fuel in float bowl on the discharge of fuel from main discharge nozzle (turn, stop, start)* • *Purpose of main jet* • *Methods of controlling fuel flow and mixture by main jet* • *Importance of shape and size of main jet on fuel flow** • *Methods of flow testing jets** • *Ways of modifying jets in the field** *(Ref. A, pp. 51-53, 70-72; Ref. C, pp. 151-153; Ref. D, pp. 125-126)*
C. Air bleeds	*Show examples and discuss the functions and operation of air bleeds. Include such items as:* • *Locations* • *Air bleeds as antipercolators* • *Tuning with air bleeds (Weber)* *(Ref. D, p. 126)*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
D. Float circuit	*Show examples and discuss the functions and operation of the float circuit. Include various types of:* • *Float bowls (metal, plastic, and glass)* • *Floats (cork, brass, plastic, and plastic foam)* • *Needle and seat assemblies (steel, plastic, and plastic tipped needles)* • *Bowl vents (inside, outside, both)*
E. Choke circuit	The choke circuit is one of the more troublesome areas of the modern automobile. Understanding its operation and providing proper service will help ensure satisfied customers. *Show examples and discuss the functions and operations of the component parts of the choke circuit. Include such items as:* • *Manual choke* • *Automatic choke* • *Choke plate and linkage* • *Thermostatic spring* • *Manifold heat control* • *Choke stove* • *Vacuum piston or vacuum diaphragm* • *Unloader* • *Electric choke (Sission and VW)* *(Ref. A, pp. 79-89; Ref. E, pp. 20-18—20-23; Ref. G, pp. 337-349)* *Demonstrate minor cleaning and adjusting of automatic chokes. Have students practice on shop engines or live cars until they become proficient in choke service. (Ref. B, pp. 160-161; Ref. E, p. 20-22)*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
F. Idle circuit	*Show examples and discuss the functions and operation of the idle circuit. Explain the relationship of the following to the idle circuit:* • *Main jet* • *Idle pickup tube* • *Idle restriction (economizer)* • *Idle air bleeds* • *Idle passage* • *Additional air bleeds (low speed ports)* • *Idle mixture screws* • *Idle r.p.m. screw (speed)* • *Idle air bypass circuit (some GM and Chrysler)* *(Ref. A, pp. 66-70; Ref. D, p. 129; Ref. G, p. 338)* *Show how the throttle position affects the operation of the idle circuit, and explain that the force involved is manifold vacuum and not venturi vacuum.*
G. Low speed circuit	*Show examples and discuss the functions and operation of the low speed circuit. When discussing low speed circuits, mention that the trade uses different names for the same item. For the sake of uniformity, be consistent with the terms used during the course. Point out that the low speed circuit:* • *Provides a transition between the idle and main circuit* • *Uses idle circuit fuel* • *Consists of additional ports or slots* • *Uses manifold vacuum, not venturi action* • *Is identified by other names (off idle—GM; intermediate—Ford)* • *Is affected by throttle position*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, pp. 67-70; Ref. D, pp. 129-130; Ref. G, pp. 321-323)
	Indicate the effect that the throttle position has on the operation of the vacuum advance in the distributor.
H. Main circuit	*Show examples and discuss the functions and operation of the main circuit. Emphasize the importance of the main circuit to overall performance and note the following:* • *Main discharge nozzle* • *Main jet* • *Venturi action* • *Boost venturi (one or more)* • *Air bleeds* • *Float level* • *Compensation and air bleed circuits* • *High speed or part throttle circuit* • *High speed jets or adjustable main jets (industrial or racing)**
	(Ref. A, pp. 52-53, 70-72)
I. Power circuit	*Show examples and discuss the functions and operation of the power circuit. Include such items as:* • *Mechanical metering rods (Carter)* • *Vacuum metering rods (Carter and Rochester)* • *Combination mechanical and vacuum metering rods (Carter)* • *Vacuum operated power valve (Stromburg and Rochester)* • *Vacuum diaphragm operated power valve (Ford, Holley, and Autolite)* • *Other types of power circuits**

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, pp. 72-75; Ref. C, pp. 153-155; Ref. G, pp. 324-325)
	Emphasize the effects of engine load and throttle position on vacuum operated power circuits.
	Secure several inexpensive vacuum gauges to loan to students for installation on their automobiles for a period of several days to show when the power circuits are in operation.
J. Accelerator pump circuit	A worn accelerator pump plunger is frequently the cause of a *flat spot* during acceleration and may be easily replaced without a carburetor overhaul.
	Show examples and discuss the functions and operation of the accelerator pump circuit. Include such items as:
	• *Piston type accelerator pump*
	• *Pump well*
	• *Inlet check valves*
	• *Outlet check valves (needle, ball, and disc)*
	• *Accelerator pump jets*
	• *Pump plungers*
	• *Return springs*
	• *Duration springs*
	• *Linkage*
	• *Diaphragm type accelerator pump (Ford)*
	• *Vacuum operated accelerator pump**
	(Ref. A, pp. 109-120; Ref. F, pp. 211-212; Ref. G, pp. 318-327)
K. Additional features	*Show examples and discuss the functions and operations of the following items:*
	• *Antipercolators*
	• *Dashpots (automatic transmission)*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Unloaders • Compensating systems • Vacuum operated secondaries • Lockouts (prevent operation of secondaries when the choke is in operation) • Air-valve controlled secondaries • Fast idle controls • Progressive carburetion (two and four barrel) • Hot idle compensators (Ref. A, pp. 97-104; Ref. C, pp. 156-159; Ref. F, pp. 212-219) Conduct student roundtable discussions to help clarify misunderstandings about carburetion.
IV. Disassembly and Reassembly	Demonstrate the specific procedure for disassembling and reassembling a carburetor, and point out the component parts and trace the various circuits. This is not to be considered carburetor service which is covered in detail in Unit 5. Include such items as: • Safety procedures • Correct tools for the job • Proper use of tools • Clean work area • Careful handling of parts • Marking parts to aid reassembly • Orderly layout of parts to aid reassembly (Ref. A, pp. 228-229; Ref. B, pp. 20-50; Ref. C, pp. 11-31) Have students practice disassembling and reassembling carburetors until they acquire the proficiency necessary for an entry mechanic. If possible, provide the same model carburetor for each member

CONTENT OUTLINE

UNDERSTANDINGS AND TEACHING APPROACHES

of the class, but no more than three students per carburetor.

Supply small trays (muffin pans, egg cartons) for the storage of the component parts of the carburetor. If conditions permit, have the students test their reassembled carburetors on a live engine.

Insist that the students follow proper work habits and procedures. Emphasize that the carburetor is a precision device and that care must be taken so that parts are not lost or damaged. If this attitude is developed at this time, later instruction will proceed more easily.

During the disassembly and reassembly of the carburetor, ask the students to identify and explain the functions and operations of the component parts and to trace the various circuits.

TOPICS FOR REVIEW

1. List the major component parts for each circuit of the carburetor.

2. Explain the function and operation of a vacuum operated power circuit.

3. Why are accelerator pumps needed? How do they work?

4. State a specific carburetor for each of the following.
   (a) Vacuum power valve
   (b) Combination vacuum and mechanically operated metering rod
   (c) Diaphragm accelerator pump
   (d) Plastic float
   (e) Plastic float bowl

5. Explain in detail the process by which the fuel is drawn through the idle circuit and the function of the devices that control the mixture in the idle circuit.

6. Identify the following from a numbered drawing of miscellaneous carburetor parts:

Float	Thermostatic spring
Power valve	Vacuum kick for choke
Needle and seat assembly	Fast idle cam
Metering rod	r.p.m. screw
Accelerator pump plunger	Idle mixture screws
Choke plate	Inlet fitting
Vacuum power piston	Main jet
Throttle plate	Accelerator pump jet
Boost venturi	Inlet filter
Bowl cover	Venturi

7. List the circuits of a carburetor.

8. Explain the function and operation of the venturi in the carburetor.

9. Explain the difference between atomization and evaporation.

10. State the normal air-fuel ratio for an automobile operating on gasoline and going 40 miles per hour.

11. State the main reason why air bleeds are incorporated in carburetors.

12. What forces the fuel into the float bowl?

13. What forces the fuel into the venturi?

14. What type of carburetor is internally vented? What would result if the air cleaner were restricted?

15. Make a simple drawing of a carburetor and show the relationships between the main jet, the main discharge nozzle, and the float level.

16. Draw and label an air-fuel ratio graph for different car speeds.

INSTRUCTIONAL MATERIALS

TEXTBOOKS

(A) Crouse, W. H. *Automotive fuel, lubricating, and cooling systems;* 4th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1971.

(B) _____ *Automotive mechanics;* 6th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1970.

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Pennsylvania Refining Company, Gumout Division. *Know your carburetor.* Cleveland, Ohio. The Division. 1971.

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Carburetor. Ethyl Corp. 1956. 8 min. sound. color. Loan — Ethyl Corp.

Carburetor, principles of operation. Norwood. 25 min. black and white. Purchase — National Audiovisual Center.

The cooling system and fuel system. 22 min. Purchase — National Audiovisual Center.

Preventing carburetor icing. Ethyl Corp. 1958. 6 min. sound. color. Loan — Ethyl Corp.

FILMSTRIPS

The fuel system. Scott Education Division. 1969. 48 frs. color. Purchase — Scott Education Division.

Fuel system, principles of operation. Ford Motor Co. 1964. 84 frs. sound. color. Purchase — Educational Affairs Dept., Ford Motor Co.

Carburetor Fundamentals

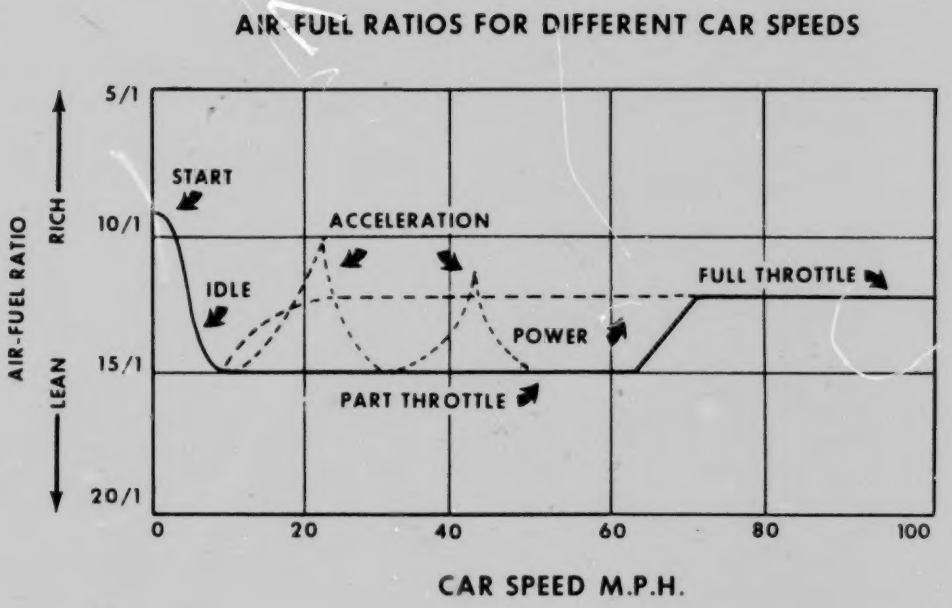
FILM LOOPS

The carburetor. 7½ min. color. sound. Purchase — Carousel Films, Inc.

TRANSPARENCIES

Engine and fuel systems. McGraw-Hill. Purchase — McGraw-Hill.

Fuel system. DCA Educational Products, Inc. Six transparencies. color. Purchase — DCA Educational Products, Inc.



Automotive Carburetors

OBJECTIVES

The student will be able:

- To explain the reason for and operation of carburetor accessories and related systems
- To explain the specific features and operation of commonly used American-made carburetors
- To explain the operation of commonly used foreign-made carburetors
- To adjust and service commonly used carburetors
- To explain the operation and service of commonly used small engine carburetors

CONTENT OUTLINE		UNDERSTANDINGS AND TEACHING APPROACHES
I.	Carburetor Accessories	*Show examples and explain the functions and operations of the following carburetor accessories:* • *Cool-air intakes (high performance)* • *Kickdown switches (overdrive and Turbo Hydra-matic)* • *Carburetor starter switches (Buick)**
II.	Carburetor Related Systems	Distributor advance problems may simulate carburetor troubles. Students need clear understandings of distributor advance systems to aid in diagnosis of these problems. *Show examples and explain the functions and operations of the following carburetor related systems:* • *Distributor advance (centrifugal and vacuum)* • *Distributor advance (full vacuum — Ford)* • *Distributor vacuum valve (Ford)*

*Important for an advanced course; may be omitted from a basic course.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Governors (velocity, centrifugal, and vacuum)*
	(Ref. A, pp. 96-101)†
	Use a distributor machine to demonstrate the vacuum and centrifugal advance of a distributor.
	Have students trace the vacuum advance passage in a carburetor body and notice its relationship to throttle position.
III. American-made Carburetors	*The carburetors discussed in this unit may become obsolete because of changes. Trade and service publications will provide current information as new carburetors are released. Develop a useful file by saving the instruction sheets from carburetor repair kits and filing them by manufacturer and type.*
	Use service training filmstrips, film loops, charts, and manuals to aid in the presentation.
A. Rochester Quadrajet carburetors	*Show examples and explain the operation of the following features of Rochester Quadrajet carburetors:*
	• *Compact float bowl (to prevent motion sensitivity)*
	• *Needle and seat assembly (unusual design on early models)*
	• *Inlet fitting threads in body (easily stripped)*
	• *Oversize inlet fitting (available for repair)*
	• *Primary metering rods*
	• *Secondary metering rod operation (air valve and cam)*
	• *Teflon coated throttle and choke shafts*
	• *Air valve operation*
	• *Specification charts*

†Textbook citations are given at the end of each unit.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, pp. 236-245; Ref. C, pp. 186-196)
	Demonstrate the required service procedures for Rochester Quadrajet carburetors.
B. Carter carburetors	Show examples and explain the operation of the following features of Carter carburetors:
	• Vacuum and mechanical metering rods
	• Metering rod adjustment
	• Plastic float bowl (Thermo Quad)
	• Main jets (retained by "O" rings — Thermo Quad)
	• Accessibility of parts requiring service
	• Air valve secondaries (AVS and Thermo Quad)
	(Ref. C, pp. 177-185; Ref. G, pp. 343-346)
	Demonstrate the required service procedures for Carter carburetors.
C. Holley carburetors	Show examples and explain the operation of the following features of Holley carburetors:
	• Diaphragm accelerator pumps
	• Fore and aft float bowls (reduce motion sensitivity)
	• Needle and seat assembly (externally adjustable float level)
	• Diaphragm type vacuum operated power valve (very rich mixture if gasket or diaphragm fails)
	• Vacuum operated secondaries (normal street operation)
	• Mechanically operated secondaries (drag racing)
	• Vacuum valve (spark control)
	• Special models (racing)
	(Ref. A, pp. 253-261)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Demonstrate the required service procedures for Holley carburetors.
D. Autolite carburetors	*Show examples and explain the operation of the following features of Autolite carburetors:* • *Diaphragm accelerator pump* • *Air valve secondaries (4300)* • *Progressive two barrel (Pinto)* • *Four-barrel inline (racing carburetor)* • *Air bleeds (interchangeable for fine tuning)* • *Manufacturer (Ford)* *(Ref. G, p. 220)* *Demonstrate the required service procedures for Autolite carburetors.*
E. Stromberg carburetors	*Show examples and explain the operation of the following features of Stromberg carburetors:* • *Model 97 (Ford and hot rod)* • *Main jet (easy external access)* • *Special jet wrench required* • *Needle and seat assembly (calibrated size on some models)* • *Power circuit (vacuum operated power valve)* *Demonstrate the required service procedures for Stromberg carburetors.* *Provide time for students to practice servicing the carburetors mentioned in III. The students should have developed sufficient skill by now to service carburetors on live cars. Concentrate most of the shopwork on the latest models available so that the students will have a broad background when they enter the trade. Have the students practice servicing carburetors until they acquire the proficiency necessary for an entry mechanic.*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
IV. Foreign-made carburetors	*Obtain samples of as many of the foreign-made carburetors mentioned as possible so that any student who expresses an interest in a particular carburetor may gain additional experience by servicing it.* *Use service training filmstrips, film loops, charts, and manuals to aid in the presentation.*
A. S.U. and Stromberg CD carburetors	The S.U. carburetor was developed by the Skinner Union Shoe Company around 1908 and is widely used on British cars. *Explain the operation of the following features of English S.U. and the similar Stromberg CD carburetors:* • *Constant vacuum type* • *Variable venturi (vacuum controlled)* • *Vacuum piston (S.U.)* • *Vacuum diaphragm (Stromberg CD)* • *Metering (one large needle and one jet)* • *Choke operation (movement of S.U. jet)* • *Jet centering and synchronizing (major service problem)* • *Dashpot (oil filled; prevents flat spot)* • *Uni-syn and other special tools* *Discuss the special tools and service procedures required for S.U. and CD carburetors.*
B. Weber carburetors	*Explain the operation of the following features of Weber carburetors:* • *Price and performance range (Fiat to Ferrari)* • *Air flow design (streamlined)* • *Venturi (interchangeable in most models)* • *Air bleed (fine tuning of mixture)*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Two barrel progressive (small high performance cars)*
	• *Engine tuning flexibility (wide range of interchangeable parts)*
C. Other*	*Explain the operation of the following foreign carburetors:*
	• *Solex (VW and Renault)*
	• *Zenith (some English Fords)*
	• *Asian (Toyota)*
	• *Nikki (Datsun)*
V. Small Engine Carburetors	*Although the following carburetors are not automotive, mechanics are called upon to service them occasionally.*
	Use service training filmstrips, charts, and manuals to aid in the presentation.
	Show examples and explain the operation and service procedures for the following:
	• *Suction-feed carburetors (some lawnmowers)*
	• *Float carburetors (lawnmowers)* *High-speed mixture adjustment must be made under load.*
	• *Diaphragm carburetors (chain saws, go-karts, and some lawnmowers)*
	(Ref. F, pp. 224-225; manufacturers' manuals)

TOPICS FOR REVIEW

1. Define the following carburetor terms: updraft, sidedraft, and downdraft.
2. Explain in detail the purpose and operation of an unloader as used in a carburetor.
3. Discuss the advantages and disadvantages of vacuum-operated carburetor secondaries for normal operation of a vehicle.
4. Discuss the advantages and disadvantages of mechanically operated carburetor secondaries for drag strip operation.

5. Discuss three types of governors; explain how each controls the speed of the engine.

6. Explain in detail the operation of a typical distributor advance system.

7. Explain in detail the operation of Ford's full-vacuum distributor advance system.

8. Explain the function and the operation of two types of carburetor antipercolators.

9. What is the major advantage of an air-valve controlled secondary in a four-barrel carburetor?

10. Explain the advantages of progressive carburetion.

11. List three popular makes of American-made automotive carburetors.

12. List three makes of foreign-made automotive carburetors.

13. Name two manufacturers of carburetors for small utility and industrial engines.

14. Explain the similarity between the operation of the secondary side of a Rochester Quadrajet carburetor and a S.U. carburetor.

15. Name an American-made four-barrel carburetor which uses a plastic float bowl.

16. Explain the advantages of using a compact float bowl.

17. Explain how to synchronize the dual S.U. carburetors on a 1250cc. MG engine. List the tools necessary.

18. Describe how to adjust the metering rods on a WCFB Carter four-barrel carburetor.

19. Explain in detail the procedure for making the float level adjustment on a late model Holley four-barrel carburetor.

20. What major difference in adjustment is required on most small engine carburetors that is not necessary on most American-made automotive carburetors?

INSTRUCTIONAL MATERIALS

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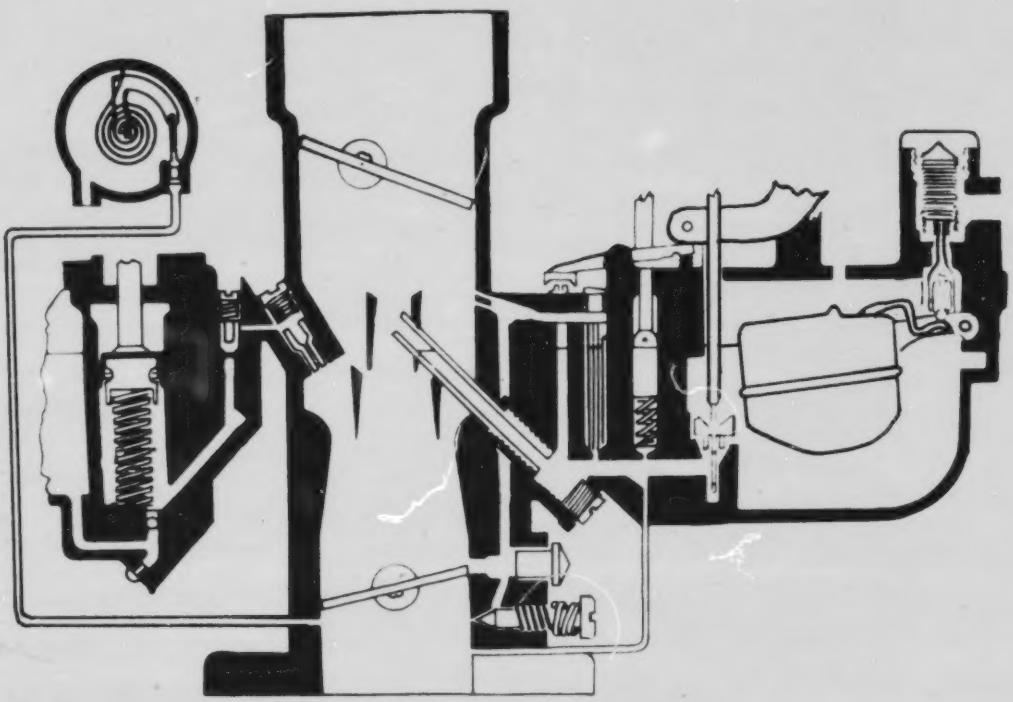

Carburetor Diagnosis and Overhaul

OBJECTIVES

The student will be able:

- To perform minor service while the carburetor is still on the engine
- To diagnose and correct carburetor malfunctions by disassembling, cleaning, reassembling, and adjusting
- To work in such a manner so as to prevent injury to himself, the equipment, and the vehicle

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Troubleshooting	Many automotive problems have similar symptoms, so the actual fault could be located in one of several systems. The following information is confined to problems related to the fuel system.
A. Fuel system test equipment	*Demonstrate and explain the operation of the following fuel system test equipment:* • *Fuel-mileage tester* • *Exhaust-gas analyzer* • *Fuel pressure gauge* • *Fuel pump capacity tester* • *Vacuum gauge* • *Compression gauge* • *Cylinder-leakage tester* • *Tachometer* • *Chassis dynamometer* • *Exhaust-emission tester (Sun infra-red)* • *Oscilloscope* • *PCV valve tester*

CONTENT OUTLINE

UNDERSTANDINGS AND TEACHING APPROACHES

(Ref. A, pp. 174-185; Ref. F, pp. 189-193; Ref. G, pp. 100-157)†

Have students practice making the following checks with available equipment:

- Miles per gallon (on students' cars, if possible)
- Vacuum, pressure, and capacity of fuel pump
- Intake manifold vacuum

  Secure several inexpensive vacuum gauges to loan to students for installation on their own automobiles for a period of several days to illustrate the effects of engine load and throttle position on intake manifold vacuum.

- Compression test (on students' cars)
- Cylinder leakage test

  For this test, use an engine with a variety of problems (burned valves, poor rings, blown head gasket), on which students already have a compression test record. Indicate that the compression test is quick, but that more information is obtainable from the cylinder leakage test.

- Idle mixture adjustment (use a vacuum gauge and then a tachometer for comparison)
- Idle r.p.m. adjustment (first by ear and then with a tachometer
- Fuel mixture test (with an exhaust-gas analyzer)
- Oscilloscope test (first of a properly operating V-8 engine, and then a retest of the same engine with the idle mixture screws out of adjustment)

  An experienced mechanic should be able to detect this fault on a scope, but

†Textbook citations are given at the end of each unit.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	it is difficult for students and not recommended as reliable practice.
	• *PCV valve test (on students' cars)*
	• *Exhaust emission test for hydrocarbons, carbon monoxide, and oxides of nitrogen (use an advanced design tester, not a normal exhaust-gas analyzer)**
	• *Chassis dynamometer test of overall engine operation**
B. Procedure	*Emphasize the need of using a logical approach when troubleshooting fuel system problems. Include such items as:*
	• *Securing a statement of problem from owner (Do not spend time looking for the wrong trouble.)*
	• *Narrowing problem to compression, ignition, or fuel*
	• *An oscilloscope will give a quick check of the ignition system.*
	• *A compression test will give an indication of the engine's general condition.*
	• *If ignition and compression test results conform to manufacturer's specifications, begin diagnosis of fuel system.*
	• *Isolating problem to a specific carburetor circuit*
	(Ref. A, p. 174; Ref. F, pp. 250-252; Ref. G, pp. 421-423)
C. Specific problems	Fuel system problems usually relate to:
	• High fuel consumption
	• Poor engine performance
	• Difficult starting

*Important for an advanced course; may be omitted from a basic course.

CONTENT OUTLINE

UNDERSTANDINGS AND TEACHING APPROACHES

Explain the methods of diagnosing and correcting the following fuel system problems:

- *High fuel consumption*
  - *Poor driving habits (high speed, lack of operator smoothness, short trips)*
  - *Excessive mechanical drag (brakes dragging, low tire pressure, improper wheel alinement)*
  - *Fuel leaks (tank, lines, filters, pump diaphragm, needle and seat assembly)*
  - *Defective operation of component parts (choke, pump, needle and seat assembly)*
  - *Improper fuel system adjustment (float level, idle mixture, choke, accelerator pump)*
- *Engine lacks power*
  - *Defective fuel pump*
  - *Clogged fuel filter, line, or tank cap vent*
  - *Abnormal operation of accelerator pump*
  - *Defective power circuit*
  - *Low float level*
  - *Dirty air cleaner*
  - *Lean mixture (air leaks into intake manifold)*
  - *Insufficient throttle opening*
  - *Restricted exhaust system*
  - *Excessively rich mixture (defective choke, float, or needle and seat)*
- *Poor idle*
  - *Poor adjustment of the idle mixture screws*
  - *Dirty idle passages*

CONTENT OUTLINE

UNDERSTANDINGS AND TEACHING APPROACHES

- Defective PCV valve
- Excessively rich mixture (defective choke, float, or needle and seat assembly)
- Excessively lean mixture (air leaks in manifold or carburetor)

• Engine stalls

- Cold (low idle r.p.m., poor idle mixture, maladjusted choke)
- Hot (low idle r.p.m., poor idle mixture, maladjusted choke, rich mixture)
- Sudden stops and high speed turns (high float level, warped bowl cover)

• Black smoky exhaust

- Improper power circuit operation (stuck power piston, defective power valve diaphragm, worn metering rod and jet)
- Inoperative heat riser valve (stuck open)
- High float level or leaky float
- Defective needle and seat assembly
- Rich mixture (worn or oversize jets, plugged air bleeds, choke stuck closed, improper choke adjustment)

• Engine runs but misses

- Dirty carburetor passageways
- Worn carburetor parts
- Maladjusted float level, power circuit, or automatic choke
- Lean mixture (air leaks)

• Engine will not start when cold

- Maladjusted choke (too lean or stuck open)
- Insufficient fuel (empty tank, defective fuel pump, or clogged line or filter)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Improper starting procedures*
	• *Engine will not start when warm*
	• *Improper air-fuel mixture (engine flooded, defective choke or float)*
	• *Insufficient fuel (empty tank, defective fuel filter or pump)*
	• *Maladjusted choke (too rich or stuck closed)*
	• *Percolation or vapor lock*
D. Quick checks of carburetor circuits	*Explain the procedures for making quick checks of the following carburetor circuits:*
	• *Float circuit*
	If the main discharge nozzle is wet when the engine is at idle speed, the float level may be too high or the needle and seat assembly may be defective.
	• *Idle and low speed circuits*
	If the engine idles rough or is rough just above an idle, there may be dirt in the passageways or the idle mixture screws may be out of adjustment.
	• *Main circuit*
	If the engine runs unevenly at normal road speeds, there may be a malfunction in the main circuit.
	• *Accelerator pump circuit*
	If the engine pops back on acceleration or if the fuel discharged from the pump jet does not seem sufficient, the accelerator pump may be defective.
	(Ref. F, pp. 250-251)
	Develop with the students a fuel system trouble-shooting chart. (Ref. A, pp. 181-195; Ref. C, p. 163; Ref. F, pp. 250-252; Ref. G, pp. 351-362; 421-423)

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Have students form teams and diagnose and correct fuel system problems in the shop engines which have been bugged by the instructor. Then students should have the opportunity of practicing on live cars until they acquire the proficiency necessary for an entry mechanic. (Ref. E, pp. 20-15—20-28)
	Warn students not to have face or hands directly over the carburetor air horn of a running engine as it may backfire and cause severe burns.
	Observe students closely for proper safety procedures during this live shop time. They may be so involved with diagnosis that they become careless.
II. Carburetor Overhaul	*Some of the following information may have been presented in Unit 3. However, it may be taught at this point in its entirety or it may be used as a review with emphasis on some of the more complex material.*
	Emphasize the need of maintaining a clean work area and of laying out parts in an orderly manner. Explain the importance of labeling parts and of noting or making index marks to aid in the reassembly of the carburetor. Indicate that if the original settings are noted, the carburetor may be installed on the engine ready to run with only minor adjustments necessary. This is especially desirable in the case of a rebuilt engine when proper break-in procedures are crucial.
A. Removal	*Demonstrate the procedures for the removal of a carburetor from an engine. Include the following:*
	• *Using seat and fender covers*
	• *Driving car in a safe and careful manner*
	• *Removing air cleaner, linkage, fuel lines, retaining nuts and washers, and carburetor (always count the nuts and washers)*
	• *Covering intake manifold opening with a cloth or cardboard (prevents foreign objects from falling into engine)*
	• *Draining gasoline into a safe container*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	(Ref. A, p. 228)
B. Disassembly	*Demonstrate the procedures for the disassembly of a carburetor. Include the following:* • *Checking identification tag number (aids in ordering the correct repair kit or parts; reinstall, as often this is the only true identification of the carburetor)* • *Using a carburetor stand to prevent damage to the throttle plates* • *Having screwdrivers that are in good condition and fit the screwheads properly* • *Disassembling the carburetor in logical sections and keeping the parts separate to aid in reassembly* • *Removing choke plates, throttle plates, or linkage only when necessary* • *Handling floats with care and marking their position for reassembly (p = primary)* • *Marking identification numbers of the main jets on carburetor body to prevent interchange during reassembly* • *Handling the accelerator pump check valves carefully and noting the position and size of the check balls* • *Saving all gaskets as a guide to reassembly* • *Noting index marks on choke cover to preserve original adjustment* • *Noting position of idle mixture screws (count number of half turns required to bottom screws as a guide to reassembly)* (Ref. A, pp. 225-260; Ref. C, pp. 168-196; Ref. E, p. 20-28)
C. Cleaning	*Demonstrate the use and handling of carburetor cleaners. Emphasize the safety procedures if a student gets some cleaner in his eyes or on his skin or clothes.*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Use only approved carburetor cleaners. Do not use gasoline or lacquer thinner because of the fire hazard. *Demonstrate the procedures for cleaning a carburetor. Include the following:* • *Using cleaner for metal parts only (floats do not normally need cleaning)* • *Preventing cleaner from coming into contact with painted or other surfaces that might be damaged* • *Using a hot tank or agitation to speed the cleaning action* • *Utilizing the recommended rinse solution (solvent in some cases, water in others)* • *Using compressed air to dry all passageways and parts* *Caution students to use care when air drying blind holes and other such areas so that materials are not blown into the eyes.* *(Ref. E, p. 20-28)*
D. Reassembly and major adjustment	*Demonstrate the procedures for the reassembly and adjustment of a carburetor. Include the following:* • *Inspecting all parts for damage, wear, or clogged passageways* • *Selecting replacement parts from repair kit* • *Reassembling internal parts (do not over-tighten)* • *Adjusting float level, drop, and alinement* • *Conditioning the accelerator pump plunger in fuel or oil if a leather cup type* • *Reassembling remaining parts* • *Adjusting accelerator pump, antipercolator, choke, unloader, and metering rod*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• Replacing idle mixture screws to approximately their original adjustment
	(Ref. E, pp. 20-15—20-30; Ref. F, pp. 249-251; Ref. G, pp. 354-360)
	Have students practice overhauling carburetors on shop engines and live cars. Students should acquire the proficiency necessary for an entry mechanic.
E. Reinstallation of the carburetor	Demonstrate the procedures for the reinstallation of a carburetor on an engine. Include the following:
	• Removing original gasket from intake manifold
	• Positioning new flange gasket correctly
	• Tightening carburetor retaining nuts evenly (do not overtighten)
	• Checking all lines for leaks
	• Making sure throttle linkage is free, particularly at full throttle
	Automobiles have been damaged when the carburetor linkage stuck at full throttle.
	(Ref. E, p. 20-29)
F. Final idle adjustment	Demonstrate the procedures for making final idle adjustments. Include the following:
	• Making all needed engine adjustments first
	• Normalizing the engine (bring up to operating temperature)
	If the original carburetor adjustments have been maintained as suggested, the engine should now run well enough to warm up properly.
	• Adjusting the r.p.m. screw to specifications by using a tachometer
	• Adjusting the idle mixture screws to secure the smoothest idle by using a tachometer or a vacuum gauge (will be the highest r.p.m. at this throttle setting)

CONTENT OUTLINE

UNDERSTANDINGS AND TEACHING APPROACHES

- *Readjusting the r.p.m. screw to specifications*
- *Rechecking idle mixture screws (with cars equipped with a smog system always finish by turning idle mixture screws in the lean direction)*
- *Road-testing, if possible, to check all ranges of carburetor operation*

(Ref. A, pp. 225-260; Ref. E, pp. 20-20—20-30; Ref. F, pp. 245-247; Ref. G, pp. 358-360)

Have students practice reinstalling and making final idle adjustments on shop engines and live cars. Students should practice until they are able to get an acceptably smooth idle within ± 10 r.p.m. of specifications.

Conduct class discussions on carburetor overhaul and adjustment so that students may benefit from each others' experiences.

Competitions such as the Plymouth Troubleshooting Contest that deal with the diagnosis and correction of minor engine malfunctions will provide extra student incentive at the secondary and community college level.

Students should be evaluated on their ability to overhaul and adjust carburetors on live automobiles. Written or oral responses might be used to test basic information, but this device should not take the place of the practical work.

TOPICS FOR REVIEW

1. How important is test equipment to an experienced mechanic?
2. List and explain the use of five types of equipment designed to test fuel systems.
3. Compare the information that is indicated by a compression gauge and a cylinder leakage tester.
4. Explain in detail how to adjust the carburetor idle mixture and engine r.p.m. using a tachometer.
5. List a quick check for each of the following: (a) fuel in the tank (b) fuel pump action (c) fuel in the carburetor.

6. Describe how to make float level, drop, and alinement adjustments; list the tools and gauges required for these adjustments.

7. Explain the reasons why the float drop adjustment is important.

8. What may happen if the float is out of alinement?

9. Explain how to check for a leaky float; describe the corrective procedures required.

10. List four special carburetor repair tools; describe when and how they are used.

11. Describe how to remove and replace the choke plate and choke shaft when servicing the vacuum piston.

12. Describe the adjustment of the accelerator pump. Why is it important to start this adjustment with the throttle plates fully seated?

13. What may happen if the carburetor bowl cover retaining screws are overtightened?

14. Describe how to make the initial automatic choke adjustment.

15. Describe what may be the result when the following are not properly adjusted: (a) antipercolator (b) unloader.

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Automotive Fuels

OBJECTIVES

The student will be able:

- To explain the various characteristics which influence the selection of an automotive fuel
- To describe the refining of gasoline

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Characteristics of Automotive Fuels	Mechanics need background information on gasoline so they can discuss customers' fuel problems.
A. Types	*Discuss practical and possible automotive fuels such as:* • *Gasoline* • *Fuel oil (diesel fuel)* • *Liquefied petroleum gas* • *Alcohol and other racing fuels** *(Ref. A, pp. 168-171; Ref. F, pp. 199-200)*†
B. Factors	*Discuss the factors which influence fuel selection such as:* • *Atomic structure** • *Hydrocarbon base* • *Volatility* • *Antiknock qualities* • *Shape of combustion chamber* • *Seasonal changes*

*Important for an advanced course; may be omitted from a basic course.

†Textbook citations are given at the end of each unit.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Octane measurement (iso-octane and heptane)*
	• *Octane measurement methods (laboratory and road research)*
	(Ref. A, pp. 153-167; Ref. B, pp. 178-181; Ref. F, pp. 200-204)
C. Fuel additives	*Explain the benefits derived from the following fuel additives:*
	• *Oxidation inhibitors*
	• *Metal deactivators*
	• *Antirust agents*
	• *Anti-icers*
	• *Detergents*
	• *Phosphorus compounds*
	• *Dye (identification)*
	(Ref. A, p. 167; Ref. F, p. 201)
	Ask students to find the octane rating and the additives contained in their favorite brands of fuel. They will find that, despite all the advertising, precise information is difficult to obtain.
D. Combustion	*Discuss combustion and its relationship to fuel blending and engine design. Include such items as:*
	• *Chemistry of combustion*
	• *Detonation*
	• *Preignition*
	• *Knock related to:* *Mechanical design of engine* *Operating conditions of engine* *Fuel*
	• *Tetraethyl lead*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	Discuss detonation and preignition. Show pictures or actual damaged engine parts, and explain how this damage occurs. (Ref. A, pp. 157-160; Ref. B, pp. 181-184)
II. Gasoline Refining	*Explain the gasoline refining process briefly. Use a film to assist in the presentation.*
III. Characteristics of Diesel Fuels and Liquefied Petroleum Gas	*Discuss the following factors which relate to diesel fuels and liquefied petroleum gas fuels:* • *Viscosity* • *Cetane number* • *Purity* • *Sulfur content* • *Boiling point of LPG (Butane 32°F. Propane -44°F.)*

TOPICS FOR REVIEW

1. List three fuels that are commercially available for internal combustion engines.
2. Discuss the refining of gasoline.
3. List the various characteristics that a good gasoline should possess.
4. List the two popular systems of octane rating; explain how the rating is obtained in each case.
5. Explain in detail the design factors which influence octane requirements for an engine.
6. Explain the blending of gasoline to match the seasonal conditions in different parts of the country.
7. Define detonation and preignition; explain why they occur.
8. List automobile operating conditions that affect the octane requirements of the engine.
9. Explain the things that a mechanic can do to reduce engine *knocking* with a specific brand and octane of fuel.
10. Why is butane not used normally as an exclusive engine fuel in a cold climate?

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Automotive Emission Control Systems

OBJECTIVES

The student will be able:

- To explain how the automobile engine affects air pollution
- To discuss the Federal and State legislation that applies to automotive emission control
- To explain the operation of commonly used automotive emission control systems
- To service commonly used automotive emission control systems

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Background	The installation of emission control systems on automobiles has caused more engine design changes than any other development in the last 30 to 40 years. At present, these systems are creating many service problems. An understanding of the operation and care of these systems is, therefore, important to the mechanic. *Discuss the following items as related to air pollution:* • *Importance of the problem* • *Air pollution in the Los Angeles Basin (smog)* • *Early control legislation* *Ask students to discuss their own experiences and beliefs relative to the air pollution problem and the importance of using automotive emission control devices.*
A. Automotive emissions	*Discuss the composition of automotive emissions; explain how and where they are formed in the automobile. Include the following items:* • *Unburned hydrocarbons* • *Carbon monoxide (CO)*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Oxides of nitrogen (NO_x)* • *Other products of combustion (lead and solid particles)* • *Crankcase blowby* • *Products of evaporation* *(Ref. A, pp. 123-136; Ref. B, pp. 169-174; Ref. C, pp. 327-358; Ref. F, pp. 220-222, 293-302, 377; Ref. G, pp. 441-457)†* *Discuss the implications of the average pollution in pounds per day per car as indicated by the following information:* *Uncontrolled 1.25 lb.* *PCV system 1.00 lb.* *1966 system .46 lb.* *1975-76 system .10 lb. (?)* *(Ref. C, p. 330)*
B. Automotive emission control legislation	*Discuss the following Federal and State automotive emission control legislation:* • *Early California laws (1960)* • *Recent Federal legislation (1971)* • *Federal legislation written for 1975-76* • *State air pollution control rules related to motor vehicles (from New York State Division of Air Resources)* • *Uniform procedures for inspection of automotive emission control devices* • *Manufacturers' problems in meeting Federal requirements* *Ask students to bring to class articles from newspapers and magazines that show the latest developments in the control of automotive emissions.*

†Textbook citations are given at the end of each unit.

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
C. Trends	*Discuss the following trends:* • *Owner revolt due to high cost of purchase and maintenance* • *Development of other power sources (steam, electric, Wankel, gas turbine, diesel, and LPG)* • *Lead-free fuels* • *Catalytic mufflers* • *Thermal reactors* • *Licenses for automotive mechanics*
II. Emission Control Systems	*Give a detailed explanation of the operation of each of the following emission control systems:* • *Clean air package (CAP)* • *Clean air system (CAS)* • *Combustion control system (CCS)* • *Improved combustion exhaust emission control system (IMCO)* • *"Engine Mod" system* • *Fuel evaporation control (FEC)* *Explain the effects that emission control devices have on engine life and performance and gasoline mileage. Because these systems change rapidly, the best sources of information are the factory repair manuals or specific emission control manuals.* *Have students examine different types of emission control systems on a variety of automobiles.*
A. Components	*Explain and illustrate the operation of the following components of emission control systems:* • *Positive crankcase ventilation valve (PCV)* • *Distributor vacuum control valve and double acting distributor diaphragm*

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Thermostatically controlled air cleaner (100° F. air intake system)*
	• *Air injection pump*
	• *Air pump relief valve*
	• *Backfire valve or "gulp valve"*
	• *Thermal switch (to advance timing under hot idle conditions)*
	• *Evaporative control system (unvented gas cap, vapor collector, vapor separator, and vapor storage unit)*
	Use cutaway units to develop understandings of the components of emission control systems.
B. Service	*Demonstrate the servicing of the following components. Emphasize the importance of maintaining factory specifications.*
	• *PCV valves and hoses*
	• *Vacuum distributor control valves*
	• *Air injection pumps*
	• *Air pump relief valves*
	• *Air intake system (100° F.)*
	• *Air intake vacuum motor*
	• *Thermal switch*
	• *Evaporative control system*
	Explain the importance of making the last turn of the idle mixture screw in the direction of a lean mixture.
	Have students practice servicing automotive emission control systems on live cars until they acquire the proficiency necessary for an entry mechanic.

TOPICS FOR REVIEW

1. Discuss the relationship of the automobile to the pollution problem.

2. List three sources of emissions from the automobile; describe the types and amounts of air pollution from these sources.

3. List three kinds of automotive emissions.

4. Describe the Federal legislation that relates to the control of automotive emissions.

5. Describe the operation of two emission control systems now in use.

6. Explain the factors in the design of the combustion chamber that affect the amount of unburned hydrocarbons produced.

7. Explain the reason that the air inlet temperature is controlled to about 100°F. in several of the emission control systems.

8. Explain the method by which the PCV valve in most emission systems is serviced.

9. Explain the methods by which changes have been made in the ignition timing during deceleration, and why these changes were necessary.

10. Contrast the catalyst converter system with the thermal reactor system for the control of automotive emissions.

INSTRUCTIONAL MATERIALS

TEXTBOOKS

(A) Crouse, W. H. *Automotive fuel, lubricating, and cooling systems;* 4th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1971.

(B) _____ *Automotive mechanics;* 6th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1970.

(C) Glenn, H. T. *Automechanics;* 2d ed. Peoria, Ill. Chas. A. Bennett Co., Inc. 1969.

(F) Toboldt, W. K. & Johnson, Larry. *Motor service's automotive encyclopedia.* Homewood, Ill. Goodheart-Willcox Co., Inc. 1969.

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Glenn, H. T. *Automotive smog control manual.* New York, N.Y. Cowles Book Co., Inc. 1968.

Glenn Mitchell Manuals, Inc. *Exhaust emission control manual.* San Diego, Calif. National Automotive Service Inc. 1971.

Milton, John, *ed. Chilton's auto repair manual.* Philadelphia, Pa. Chilton Book Co. 1971.

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General Motors Corporation, AC Spark Plug Division. *Crankcase and exhaust emission systems.* Flint, Mich. The Division. 1969.

New York State Division of Air Resources. *Air pollution control rules and amendments for motor vehicle exhaust.* Albany, N.Y. The Division.

FILMS

Air pollution and cars. General Motors Corp. 16½ min. sound. color. Loan — General Motors Corp.

Air pollution - everyone's problem. 1965. 20 min. sound. color. Rent — State University of New York at Albany, Film Service.

The answer is clear. CRS Productions. 1967. 14 min. sound. color. Loan — General Motors Corp.

Automotive emission control. Ethyl Corp. 1969. 25 min. sound. color. Loan — Ethyl Corp.

Positive crankcase ventilation. Ethyl Corp. 1966. 16 min. sound. color. Loan — Ethyl Corp.

To clear the air. American Petroleum Institute. 1967. 20 min. sound. color. Loan — New York State Petroleum Council.

FILMSTRIPS

Air pollution and you. Current Affairs Films. 1967. 46 frs. color. Purchase — Current Affairs Films.

Smog and your automobile. California Air Resources Board. 1971. 150 frs. color. Purchase — Vista Productions.

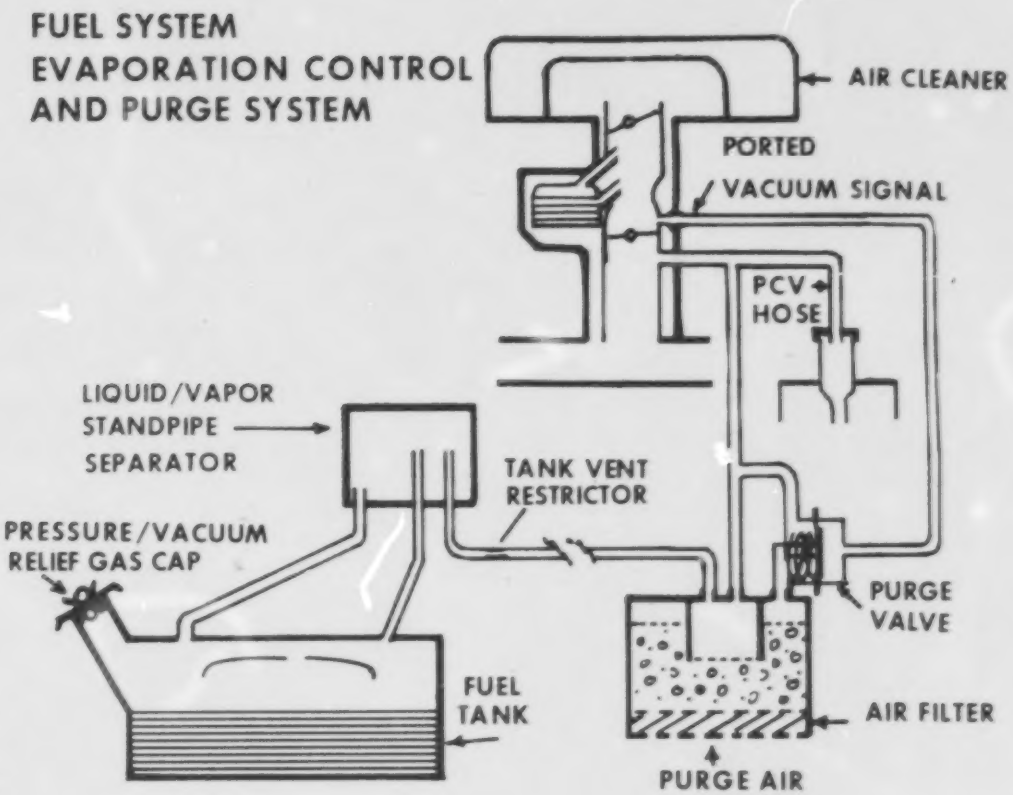
FILM LOOPS

Crankcase ventilation systems - testing procedures. DCA Educational Products, Inc. sound. color. Purchase — DCA Educational Products, Inc.

TRANSPARENCIES

Air pollution control devices for automobiles. Creative Visuals. Purchase — Creative Visuals.

Emission control systems. DCA Educational Products, Inc. Six transparencies. color. Purchase — DCA Educational Products, Inc.



Fuel Injection, Superchargers, and Liquefied Petroleum Gas Systems

OBJECTIVES

The student will be able:

- To explain the operation and service of several types of fuel injection systems
- To explain the operation and service of several types of superchargers
- To explain the operation of the liquefied petroleum gas system

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
I. Fuel Injection Systems	Fuel injection provides each cylinder with an equal amount of fuel which is supplied under pressure. *Analyze the reasons for the development of fuel injection and discuss the following:* • *Background** • *Diesel injection* • *High performance* • *Efficiency for emission reduction* • *Future use*
A. Types	*Explain the operation of the following types of fuel injection systems:* • *Diesel fuel injection (common rail and Bosch)* • *Bosch direct gasoline injection (Mercedes 300 SL)* • *Bosch mechanical injection (intake manifold)* • *Constant flow port injection (Hilborn and Corvette)*

*Important for an advanced class; may be omitted from a basic course.

CONTENT OUTLINE		UNDERSTANDINGS AND TEACHING APPROACHES
		• *Electronic port injection (Bosch-VW)*
		• *Outlook*
		(Ref. D, pp. 148-150; Ref. F, pp. 270-285)†
	B. Service	*Discuss the service requirements for fuel injection systems including:*
		• *High standards*
		• *Training required*
		• *Specialized equipment*
		If one is available, show a fuel injection equipped engine, and point out the various components.
II.	Superchargers	A supercharger may be used to increase the horsepower of an engine.
	A. Types	*Show examples and explain the operation of the following types of superchargers:*
		• *Centrifugal (Cord and Paxton)**
		• *Roots (GM)*
		• *Vane (Judson)*
		• *Axial flow (Latham)**
		• *Turbochargers (Olds F-85, Corvair, and diesel trucks)*
		(Ref. A, pp. 121-123; Ref. D, pp. 148-149; Ref. F, pp. 259-263)
	B. Service	*Discuss the servicing of turbochargers, and demonstrate procedures if there is a unit available.*
III.	Liquid Petroleum Gas Systems	Liquid petroleum gas produces less air pollution than normal gasoline.
		Explain the operation of an LPG system including the following items:

†Textbook citations are given at the end of each unit.

Fuel Injection, Superchargers, and Liquefied Petroleum Gas Systems

CONTENT OUTLINE	UNDERSTANDINGS AND TEACHING APPROACHES
	• *Background* • *Types (propane and butane)* • *CNG (compressed natural gas)* • *Uses (trucks, tractors, stationary engines, and for automotive emission reduction)* • *Components of system (tank, regulator, and carburetor)* *(Ref. A, pp. 150-151; Ref. D, p. 150; Ref. F, pp. 265-269)* *Demonstrate an engine equipped with an LPG system. Discuss service procedures.*
IV. High Performance Equipment*	*Explain the operation of high performance equipment and discuss its advantages and disadvantages. Include such items as:* • *Additional carburetion* • *Venturi area* • *Power air-fuel ratios* • *Tuned intake manifolds (ram tubes)* • *Tuned exhaust systems (headers)* • *"Racing" camshafts* • *Low restriction or no mufflers* • *Carburetor modifications for racing* *(Ref. A, pp. 120-121; Ref. D, pp. 143-145; Ref. F, pp. 288-289)*

TOPICS FOR REVIEW

1. Explain the operation of the VW fuel-injection system.
2. List four types of superchargers.
3. Explain in detail the operation of a turbocharger.
4. Give five advantages of using LPG as an automotive fuel.

5. Explain the function of the components of an LPG system.

6. Contrast the differences between the common rail and the Bosch high pressure diesel fuel injection systems.

7. List the major components of the VW fuel injection system, and explain the type of diagnosis used on these components.

8. Give several reasons why the American automotive industry may adapt electronic fuel injection.

9. Discuss the reasons why turbochargers are used extensively in the trucking industry but not in the automobile industry.

10. Indicate on a schematic drawing of a turbocharger installation for a four cylinder four-stroke cycle diesel engine the intake and exhaust manifolds, sealing rings, and oil supply. Show the flow of the air and exhaust by the use of arrows. Discuss the operation of the turbocharger and explain why the impellers need to be carefully balanced.

INSTRUCTIONAL MATERIALS

TEXTBOOKS

(A) Crouse, W. H. *Automotive fuel, lubricating, and cooling systems;* 4th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1971.

(B) _____ *Automotive mechanics;* 6th ed. New York, N.Y. McGraw-Hill Book Co., Inc. 1970.

(C) Glenn, H. T. *Automechanics;* 2d ed. Peoria, Ill. Chas. A. Bennett Co., Inc. 1969.

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(E) _____ *Auto services and repair.* Homewood, Ill. Goodheart-Willcox Co., Inc. 1969.

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Elfrink, Henry. *Volkswagen fuel injection technical manual.* Los Angeles, Calif. Henry Elfrink Automotive. 1969.

Fisher, C. H. *Carburetion;* 4th ed. (4 vol.). London, England. Chapman and Hall. 1963-69.

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_____ *Glenn's foreign carburetors and electrical systems guide.* Philadelphia, Pa. Chilton Book Co. 1965.

Judge, A. W. *Carburetors and fuel injection systems,* vol. 2. Cambridge, Mass. Robert Bentley, Inc. 1965.

Schofield, Miles. *Basic carburetion and fuel systems.* Los Angeles, Calif. Peterson Publishing Co. 1971.

Smith, P. H. *The design and tuning of competition engines;* 4th ed. rev. Cambridge, Mass. Robert Bentley, Inc. 1967.

_____ *The scientific design of exhaust and intake systems;* 2d ed. Cambridge, Mass. Robert Bentley, Inc. 1968.

_____ *Tuning for speed and tuning for economy;* 4th ed. Cambridge, Mass. Robert Bentley, Inc. 1970.

FILMS

The ABC of the diesel engine. General Motors Corp. 1950. 18 min. sound. color. Loan — General Motors Corp.

FILM LOOPS

The 2-cycle engine. Carousel. 4 min. color. sound. Purchase — Carousel Films, Inc.

Final Examination

Final Examination Part I — Fill-In Statements

Directions: For each statement, write the word or phrase that, when inserted in the blank, will complete the statement correctly.

1. When the engine is under a load, extra fuel is supplied by the POWER CIRCUIT.
2. The device that regulates the air-fuel mixture during warmup is called the CHOKE.
3. The ideal air-fuel ratio for power is 12:1.
4. The main purpose of the air bleed in the main discharge nozzle is to improve fuel ATOMIZATION.
5. The device that provides most drivers with control over a flooded engine is called the UNLOADER.
6. In a typical carburetor, turning the idle mixture screw *in* will make the mixture LEANER.
7. A reddish stain around the carburetor bowl cover is a sign that the float level is TOO HIGH.
8. If gasoline is leaking from the vent of a fuel pump, it is an indication there may be a hole in the fuel pump DIAPHRAGM.
9. The device in the power circuit that passes through the main jet is called a METERING ROD.
10. If a stream of gasoline is being discharged from the bowl vent during cranking the most common cause is a LEAKY FLOAT.
11. When the dash knob of a manual choke is pulled all the way out, the choke valve should be fully CLOSED.
12. To properly adjust the automatic choke, the engine should be completely COLD.
13. The normal number of idle mixture screws in most four-barrel carburetors is TWO.
14. The most common problem with manifold heat control valves is STICKING.
15. The normal number of check valves in most accelerator pump circuits is TWO.

Final Examination Part II — Multiple Choice

Directions: For each statement, place an X in the space to the left of the choice that completes the statement most accurately.

1. The four strokes of the Otto cycle in order of occurrence are

_____ (a) intake, power, exhaust, and compression
_____ (b) exhaust, power, compression, and intake
__X__ (c) compression, power, exhaust, and intake
_____ (d) power, intake, compression, and exhaust

2. Two of the products formed when gasoline burns completely are

_____ (a) oxygen and hydrocarbons
_____ (b) carbon and oxygen
__X__ (c) water and carbon dioxide
_____ (d) water and oxygen

3. Fuel is delivered from the fuel pump to the carburetor by the

_____ (a) rocker-arm pull
__X__ (b) diaphragm-spring pressure
_____ (c) float-bowl vacuum
_____ (d) manifold vacuum

4. A balanced carburetor is one which is vented

__X__ (a) into the airhorn
_____ (b) through the bowl cover
_____ (c) into the intake manifold
_____ (d) into the exhaust manifold

5. During low-speed operation when the throttle is only slightly open, most of the fuel supplied to the engine is discharged through the

__X__ (a) idle and low-speed ports
_____ (b) main discharge nozzle
_____ (c) boost venturi
_____ (d) accelerator pump jet

6. During full throttle operation, most of the fuel supplied to the engine is discharged through the

_____ (a) idle port
_____ (b) low-speed port
__X__ (c) main discharge nozzle
_____ (d) accelerator pump jet

7. The breaking up of a liquid into fine droplets is called

_____ (a) evaporation
_X_ (b) atomization
_____ (c) venturi effect
_____ (d) carburetion

8. Fuel from the accelerator pump circuit is forced into the manifold by a

_____ (a) check valve
_____ (b) metering rod
_____ (c) discharge nozzle
_X_ (d) piston

9. A dual carburetor has an accelerator pump circuit with two

_____ (a) metering rods
_____ (b) pumps
_____ (c) pistons
_X_ (d) jets

10. In a properly tuned system, the correct air-fuel ratio during normal operation is about

_____ (a) 9:1
_____ (b) 12:1
_____ (c) 13:1
_X_ (d) 14.5:1

11. Knocking may result from

_____ (a) vaporization
_X_ (b) detonation
_____ (c) humidity
_____ (d) low compression

12. As the full-power circuit of the carburetor begins to function, additional fuel is delivered to the main nozzle by the movement of a

_____ (a) thermostatic butterfly valve
_X_ (b) vacuum piston or vacuum diaphragm
_____ (c) thermostat and vacuum piston
_____ (d) unloader

13. The accelerator pump circuit prevents a lean condition

_____ (a) during deceleration
_X_ (b) when the throttle is opened quickly
_____ (c) when the choke is open
_____ (d) when the choke is closed

14. When the choke is closed, the air-fuel ratio will be about

__X__ (a) 9:1
_____ (b) 12:1
_____ (c) 13:1
_____ (d) 15:1

15. The purpose of connecting the accelerator pump piston to the throttle linkage through a spring is to give the fuel spray from the accelerator pump

_____ (a) more pressure
__X__ (b) longer duration
_____ (c) shorter duration
_____ (d) higher velocity

16. When the engine is cold, the manifold heat control valve diverts the exhaust gases

__X__ (a) through a separate passageway in the intake manifold
_____ (b) around the exhaust manifold
_____ (c) directly from the exhaust valves to the exhaust pipe
_____ (d) around the muffler

17. A vacuum operated device in the automatic choke is used to improve

_____ (a) high speed operation
_____ (b) hot idle operation
__X__ (c) cold engine driveaway
_____ (d) deceleration

18. The fast-idle cam is operated by linkage connected to the

_____ (a) throttle shaft
_____ (b) idle-mixture screw
__X__ (c) choke valve
_____ (d) air cleaner

19. The purpose of the antipercolator is to prevent raw gas from being discharged from the

_____ (a) idle port
_____ (b) low speed port
_____ (c) needle and seat assembly
__X__ (d) main discharge nozzle

20. The float circuit controls the level of fuel in the

_____ (a) idle passage
_____ (b) main jet
__X__ (c) main discharge nozzle
_____ (d) accelerator pump jet

21. The spark advance activated by the intake manifold vacuum does not occur until the throttle is

_____ (a) fully closed
__X__ (b) open a small amount
_____ (c) wide open
_____ (d) at least half open

22. Distributor centrifugal spark advance is related directly to

__X__ (a) engine r.p.m.
_____ (b) intake manifold vacuum
_____ (c) throttle position
_____ (d) engine load

23. The purpose of the dashpot on cars equipped with automatic transmissions is to

_____ (a) aid the transmission during kickdown
__X__ (b) prevent stalling when stopping
_____ (c) allow the throttle to close more rapidly
_____ (d) slow accelerator pump action

24. The purpose of a governor installed on trucks is to

_____ (a) hold the engine at a constant speed
__X__ (b) prevent the engine from overrevving
_____ (c) aid the brakes on a downhill grade
_____ (d) prevent the engine from stalling

25. Fuel is supplied directly to the airstream during normal crusing by the action of the

_____ (a) fuel pump
_____ (b) float
__X__ (c) venturi
_____ (d) accelerator pump

26. The word *smog* was coined from

_____ (a) hydrogen and carbon dioxide
_____ (b) hydrogen and carbon monoxide
__X__ (c) smoke and fog
_____ (d) unburned hydrocarbons

27. In the velocity-type governor, the throttle plate tends to move toward the closed position as the velocity of the air-fuel mixture through the carburetor air horn

__X__ (a) increases
_____ (b) decreases
_____ (c) strikes a balance
_____ (d) reaches an idle speed

28. An engine equipped with the CAP emission control system should have an idle air-fuel mixture of

_____ (a) 0.142
_____ (b) 1.42
__X__ (c) 14.2
_____ (d) 0.014

29. Other conditions being equal, opening the throttle wide

_____ (a) reduces the tendency to knock
__X__ (b) increases the tendency to knock
_____ (c) raises the compression ratio
_____ (d) decreases the compression ratio

30. Emission control systems that regulate the temperature of the inlet air, operate at

_____ (a) 50°F.
__X__ (b) 100°F.
_____ (c) 200°F.
_____ (d) 300°F.

31. Gasoline is a volatile mixture containing

_____ (a) oxygen and nitrogen
_____ (b) hydrogen and oxygen
_____ (c) carbon and oxygen
__X__ (d) hydrogen and carbon

32. At top speed with all four barrels open, a properly operating four-barrel carburetor should produce an air-fuel ratio of

_____ (a) 9:1
_____ (b) 10:1
__X__ (c) 12:1
_____ (d) 15:1

33. The purpose of installing more than one carburetor on an engine is to

_____ (a) improve fuel economy
__X__ (b) improve breathing ability
_____ (c) permit a lower hood design
_____ (d) provide an impressive engine

34. The power to run the compressor of a turbocharger is supplied by engine

_____ (a) vacuum
_____ (b) compression
_____ (c) power
__X__ (d) exhaust

35. A liquefied petroleum gas system does not use a

_____ (a) fuel tank
_X_ (b) fuel pump
_____ (c) carburetor
_____ (d) manifold

36. When compared to manifold vacuum, venturi vacuum is

_X_ (a) much less
_____ (b) the same
_____ (c) greater
_____ (d) much greater

37. A diesel engine does not use a (an)

_____ (a) injector
_____ (b) fuel pump
_X_ (c) ignition coil
_____ (d) camshaft

38. In the Quadrajet carburetor, the primary throttle plates are

_____ (a) the same size as the secondary throttle plates
_X_ (b) much smaller than the secondary throttle plates
_____ (c) slightly larger than the secondary throttle plates
_____ (d) much larger than the secondary throttle plates

39. A black smoky exhaust is due to a

_____ (a) lean mixture
_____ (b) rich mixture
_X_ (c) very rich mixture
_____ (d) poor piston rings

40. If the main discharge nozzle in the carburetor air horn is wet when the engine is running at idling speed, then probably the

_____ (a) float level is too low
_X_ (b) float level is too high
_____ (c) fuel line is clogged
_____ (d) accelerator pump is defective

41. The most commonly used fuels for internal combustion engines are

_____ (a) coal, coke, and oil
_X_ (b) gasoline, oil, and liquefied petroleum gas
_____ (c) alcohol, gasoline, and liquefied petroleum gas
_____ (d) alcohol, nitro, and gasoline

42. Vapor lock is most apt to occur in the

__X__ (a) fuel lines
_____ (b) fuel tank
_____ (c) carburetor
_____ (d) vent line

43. The antiknock value of gasoline is referred to in terms of

__X__ (a) octane number
_____ (b) volatility number
_____ (c) compression number
_____ (d) heptane number

44. The two gaseous petroleum compounds that are most widely used for liquified petroleum gas are

_____ (a) propane and heptane
_____ (b) propane and cetane
_____ (c) propane and octane
__X__ (d) propane and butane

45. *Carburetor icing* takes place

_____ (a) in the fuel pump
_____ (b) at the air inlet of the carburetor
__X__ (c) at the edge of the throttle plate
_____ (d) in the fuel filter

46. When adjusting the idle mixture screw, the mechanic should

_____ (a) open the screw all the way
_____ (b) use as little air as possible
__X__ (c) use as much air as possible
_____ (d) close the screw all the way

47. Fuel level in the float bowl is best adjusted by

_____ (a) adjusting fuel pump pressure
_____ (b) changing the seat diameter of the needle and seat assembly
_____ (c) altering the main jet size
__X__ (d) bending the float needle contact arm

48. The preferred method for cleaning carburetor jets is to

_____ (a) run a drill through the jet
_____ (b) run a soft wire through the jet
_____ (c) blowout with an air blast
__X__ (d) run a soft wire through and then blowout with an air blast

49. The VW's electronic fuel injection system delivers fuel directly into the

_____ (a) carburetor
_____ (b) intake manifold
__X__ (c) intake port
_____ (d) combustion chamber

50. The *brain* of the Bosch and Bendix fuel injection systems could be called

_____ (a) mechanical
_____ (b) pneumatic
_____ (c) hydraulic
__X__ (d) electronic

Final Examination Part III — Matching

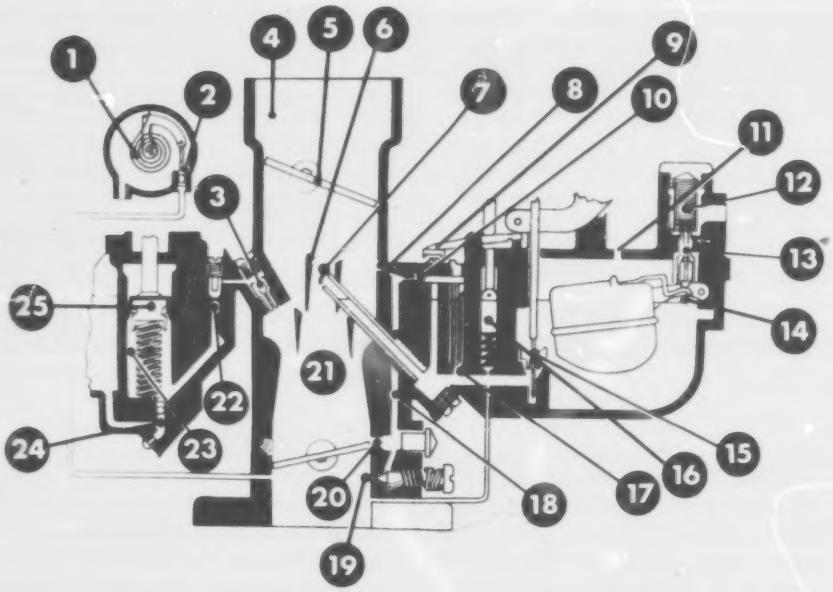
Directions: In the space provided to the left of each item in Column I, write the letter of the word or phrase from Column II which best defines the item in Column I.

I	II
__F__ 1. Metering rod	A. Part of float circuit
__C__ 2. Lockout	B. Prevents discharge of raw fuel into venturi
__H__ 3. Duration spring	C. Prevents secondaries from opening when engine is cold
__A__ 4. Needle and seat assembly	D. Float adjustments
__B__ 5. Antipercolator	E. Improves atomization
__K__ 6. Vacuum kick	F. Part of the power circuit
__D__ 7. Alinement, drop, and level	G. Controls engine speed
__G__ 8. Governor	H. Part of pump plunger
__E__ 9. Air bleed	I. Equalizes pressure
__I__ 10. Bowl vent	J. Air-fuel ratio
	K. Improves choke operation
	L. Low-speed circuit

Final Examination Part IV — Identification

Directions: In the space provided after each number, write the correct name of the part indicated by the matching number on the illustration given below.

1. THERMOSTATIC SPRING
2. VACUUM PISTON
3. PUMP JET
4. AIR HORN
5. CHOKE PLATE
6. BOOST VENTURI
7. MAIN DISCHARGE NOZZLE
8. AIR BLEED
9. ANTIPERCOLATOR
10. METERING ROD
11. BOWL VENT
12. INLET SCREEN
13. NEEDLE AND SEAT
14. FLOAT LEVEL
15. MAIN JET
16. VACUUM POWER PISTON
17. IDLE TUBE
18. IDLE PASSAGE
19. IDLE PORT
20. LOW SPEED PORT
21. VENTURI
22. OUTLET CHECK
23. PUMP WELL
24. INLET CHECK
25. PLUNGER



Using Audiovisual Materials

Audiovisual materials are both a tool for teaching and an avenue for learning. While no particular amount of time is recommended for using audiovisual materials, it is suggested that they be used with a variety of other learning activities and that the instructor not devote an entire class session to the use of such materials.

Audiovisual materials lend themselves well to stimulating a high level of involvement. When working with adults, it is well to remember that they can learn much from each other. It is with the idea of getting people involved and having them make contributions that these comments are made.

The following suggestions may assist the instructor as he plans for the effective use of audiovisual materials.

- Plan presentation (organization and methods)
- Prepare equipment and materials
- Orient class (background material)
- Present lesson
- Summarize concepts and understandings
- Evaluate knowledges acquired
- Followup with opportunities to explore new knowledges
- Return equipment and materials

Plan Presentation (Organization and Methods)

Always preview any audiovisual material to become familiar with its content and to see that it correlates with the lesson. Adult students dislike *time fillers* and inappropriate presentations. While previewing, prepare comments which might answer such questions as:

- What is being illustrated?
- Why is the presented material important?
- What are the important terms and understandings being presented?
- What are some appropriate topics which could be used to stimulate class discussions?

Prepare Equipment and Materials

Request the required equipment several days ahead of time from the director of adult education or person in charge of audiovisual equipment. Then, see that it is delivered prior to the starting of the class. Check the equipment to see that it is all in working order. Before the class begins, practice using the equipment to become acquainted with its operation. Arrange the room so that everyone can see and is comfortable. Have a screen ready and place it so that the least amount of outside light is reflected

onto it. The wall may be used, but a screen is much more desirable. The larger the room and the larger the audience, the larger the screen that is needed. Be sure there is a table for the projector, an electrical outlet, an extension cord, and a spare projector lamp in case the one in use fails.

If the class is held during the day, be sure the room can be darkened and ventilated. Check to see that the lights can be turned off without shutting off the power to the projector. At the conclusion of the presentation, allow the fan on the machine to cool the equipment for a few minutes before completely shutting off the power.

Orient Class (Background Material).

Explain the subject matter that is going to be presented. Discuss the important terms used, and indicate the main points that will be covered.

Present Lesson

Have the film threaded and the projector ready for use. Stop the film or filmstrip for discussion as the need arises during the showing instead of waiting until the presentation has been completed. A filmstrip offers flexibility, for it may be used as a whole or as a part, whichever is appropriate to the needs of the trainees. It may also be stopped at any frame for discussion or questions. At the end of the showing, make your comments and encourage discussion and questions from the trainees.

Summarize Concepts and Understandings

Itemize the important learnings on the chalkboard as they are contributed by the class. Allow time for the trainees to raise other questions which may lead to a more complete understanding of the topic. Encourage trainees to keep some kind of notation for future review.

Evaluate Knowledges Acquired

Prepare a list of questions which might assist trainees to evaluate how well they have learned the important points of the presentation. One approach might be for the instructor to present the question and pause for a few moments to allow the trainees to form their answers before responding. Interest could be generated by asking the trainees to keep track of the number of their correct answers.

Followup With Opportunities To Explore New Knowledges

Introduce several new topics for discussion which will motivate the trainees to a further investigation of the subject.

Return Equipment and Materials

After the class is over, make arrangements to return the equipment and school-owned audiovisual materials. For an item ordered from an out-of-school source, complete the required attendance report, prepare the material for mailing, and make arrangements for its prompt return.

Preparing and Using Transparencies

Materials for use on the overhead projector may be prepared by hand, the heat-transfer process, and the color-lift process. Each method is described briefly for those who might wish to make their own original transparencies.

General Suggestions

- Select only content that is appropriate for an overhead transparency.
- Keep content of transparency simple.
- Organize the content of the transparency carefully.
- Use multiple overlays (one transparency over another) for the development of a concept or to show steps.
- Keep master and overlays in register with crosshair marks in opposite corners.
- Use color to make the transparency attractive but only enough color for emphasis. Color-toned sheets or colored ink may be used to identify parts of a drawing or picture.
- Plan transparency for horizontal projection.
- Use letters and symbols that are at least $\frac{1}{4}$-inch high. Use a lettering guide or dry-transfer letters and symbols to produce attractive titles or labels.
- Leave a $\frac{3}{4}$-inch clear margin on all sides of the transparency.
- Use a pointer to identify a specific part and then remove it quickly or lay pointer on transparency, for a hand-held pointer cannot be kept steady and is distracting.
- Use a sliding or hinged mask to control the rate of disclosure when more than one step is included on a transparency.

Handmade Process

Produces a simple and inexpensive transparency.

Materials Needed

Plastic sheet or roll - clear or frosted

Markers - grease pencil or pen
Ink - transparent or india

Suggested Procedures

- Mark directly on the plastic sheet. This may be done in front of the class as the lesson is being given or may be prepared ahead of time.

- Remove materials placed on a handmade transparency with a sponge or cloth moistened with water or a special cleaning fluid. Then the transparency is ready to be used again.

Heat-Transfer Process

Produces a transparency from almost any original that is flexible and no thicker than a sheet of paper.

Materials Needed

Plastic sheets
Item to be copied
Copying machine

Suggested Procedures

- Material to be copied can be opaque or translucent but should have a carbon-type ink base *(black)*.

- Follow the directions for the specific copying machine; use the recommended type of plastic sheets.

Color-Lift Process — Drymount Press

Produces a transparency by transferring the ink of a printed picture to a sheet of transparent film. Only material printed on a clay-based paper may be used.

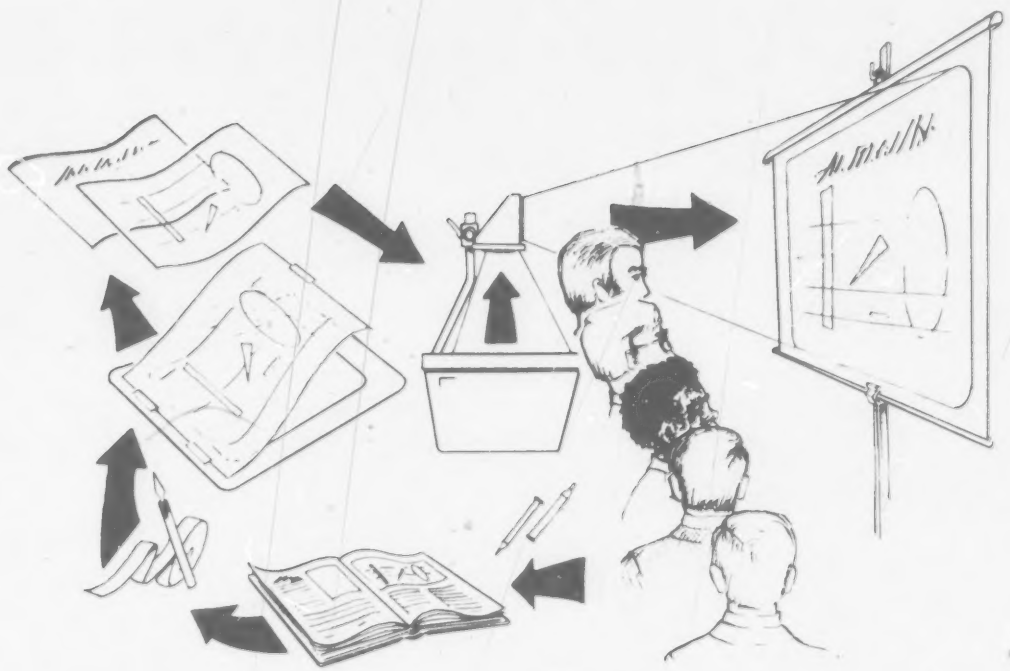
Materials Needed

Special film
Detergent
Flat tray
Drymount press
Pressure boards
Item to be transferred

Suggested Procedures

- Select and test the picture to be lifted. Wet the fingertip and rub over an unprinted portion of the page. Clay-based papers will leave a white residue on fingertip.

- Dry the picture for 5 seconds in a drymount press at 270° F.
- Put the picture on the coated side of the special film and place between pressure boards. Heat the resulting sandwich for 2-3 minutes in a drymount press set for 270° F.
- Place picture and film in lukewarm water containing a liquid detergent. Soak for 2 minutes or until the paper pulls easily from the acetate.
- Wash clay coating from picture and dry film carefully.
- Spray ink surface with clear lacquer spray. Allow spray to dry; then mount transparency.



Glossary

Accelerator: A pedal that activates the carburetor throttle valve.

Accelerator pump: A small pump in the carburetor that sprays additional gasoline into the airstream during acceleration.

Additive: A substance that is added to gasoline or oil to improve its original characteristics.

Afterburner: A device installed in the exhaust system to burn raw fuel in the exhaust gases.

Air bleed: A small opening through which air may be added to the gasoline or air-fuel mixture as it flows through the passage.

Air cleaner: A device on the carburetor that filters foreign particles from the air entering the engine.

Air-fuel mixture: The combination of air and fuel that is delivered to the engine by the carburetor.

Air-fuel ratio: The ratio by weight of air to fuel as they enter the cylinder.

Air horn: The air inlet of the carburetor.

Air-injection system: A device that adds air to the exhaust manifold to help burn raw fuel in the exhaust gases.

Air pressure: The pressure developed by the weight of air pressing downward on an object (14.7 p.s.i. at sea level).

Ambient: Surrounding on all sides.

Antiknock: A characteristic of fuels that resists detonation.

Antipercolator: A device that vents the carburetor bowl to prevent raw fuel from being pushed out of the main discharge nozzle.

Antismog device: A device or system designed to reduce air contaminants given off to the outer air from a motor vehicle engine.

API: American Petroleum Institute.

Atmospheric pressure: The pressure developed by the weight of air pressing downward on an object (14.7 p.s.i. at sea level).

Atomization: The breaking up of a liquid into very find particles.

Automatic choke: A device that regulates the choke plate according to engine temperature.

Backfire: An explosion of the air-fuel mixture in the intake manifold, carburetor, or air cleaner.

Back pressure: A resistance to the flow of gases, such as a restriction in the exhaust system.

Balanced carburetor: A carburetor which has the float bowl vented to the inside of the air horn.

Ball check valve: A valve consisting of a ball and seat that allows movement in one direction only.

Barrel: The part of the carburetor in which the venturi is located.

BDC: Bottom dead center.

Benzol: A byproduct of the manufacture of coke.

Bimetal: A special combination of metals with different expansion rates that are often made into thermostatic springs which operate such devices as automatic chokes, manifold heat controls, and hot-idle compensators.

Blowby: A leakage or loss of pressure.

Bottom dead center: The lowermost point of piston travel.

Brake horsepower, b.hp.: A measurement of the actual power produced by an engine.

Breather: A tube or opening that allows air and vapors to circulate throughout the engine..

British thermal unit, B.t.u.: A measurement of the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Butane: A type of liquefied petroleum gas.

Butterfly valve: A device that controls air flow; a term used in conjunction with the choke and throttle.

Calibrate: Adjusting the dial needle of a test instrument to the correct initial or zero setting.

Cam: A disc mounted off center to provide a variation in motion.

Carbon dioxide: A gas resulting from the combustion of fuel.

Carbon monoxide: A poisonous gas produced by the combustion of fuel.

Carburetion: The mixing of air and fuel in the correct proportions to form a combustible mixture.

Carburetor: A device that vaporizes and mixes gasoline with air in the correct proportions for the operation of a gasoline engine.

Carburetor icing: The formation of ice on and around the carburetor throttle plate during certain atmospheric conditions.

Catalyst converter: A device installed in the exhaust system that converts harmful gases into harmless gases.

Cetane: A rating of the ease with which a diesel fuel ignites.

Change of state: The conversion of a solid to a liquid, or a liquid to a gas or vice versa.

Choke: A device that controls the flow of air in the carburetor to enrich the mixture.

Choke stove: A heated compartment in or on the exhaust manifold which provides hot air for the operation of the automatic choke.

Closed crankcase ventilating system: A system in which crankcase vapors are drawn into the intake system to prevent the escape of unburned hydrocarbons into the air.

CO: Carbon monoxide.

CO_2: Carbon dioxide.

Combination fuel pump: The combination of a fuel pump and a vacuum booster pump.

Combustion: The rapid burning of the air-fuel mixture in the cylinder.

Combustion chamber: The space where the burning of the fuel mixture takes place.

Compensating circuit: A special circuit in some carburetors that provides a balanced air-fuel mixture under all conditions.

Compression gauge: A device which measures the amount of pressure developed in the cylinder during cranking.

Compression ratio: The ratio between the volume in the cylinder with the piston at bottom dead center (BDC) and the volume with the piston at top dead center (TDC).

Compression stroke: The movement of the piston from botton dead center (BDC) to top dead center (TDC) when both valves are closed.

Concentric: Two circles having the same center but different diameters.

Crankcase delution: The thinning of lubricating oil in the pan by liquid gasoline seeping down the cylinder walls past the rings.

Crankcase ventilator: A device that allows air to circulate through the crankcase.

Cycle: The series of events that recur regularly such as the piston strokes of intake, compression, power, and exhaust.

Cylinder: The tubular opening in which the piston moves.

Dashpot: A device used to slow down or delay the operation of some moving part.

Detergent: A substance added to gasoline to aid in cleaning the fuel system.

Detonation: The explosion of the air-fuel mixture during combustion.

Diagnosis: The process by which the cause of a malfunction is determined.

Diaphragm: A flexible membrane that separates the two parts of a closed container.

Distillation: The boiling of a liquid and the condensation and collection of the resulting vapors.

Downdraft carburetor: A carburetor in which the air passes down through the venturi on its way to the engine.

Dual carburetor: A carburetor with two venturi.

Dual carburetors: Two carburetors.

Dynamometer: A device that measures the power output of an engine.

Economizer valve: A device installed in the carburetor to provide a leaner mixture when power is not required.

EEC: Evaporation emission control (emission control system).

EGR: Exhaust gas recirculation (emission control system).

Emission control device: A device or system designed to reduce air contaminants expelled into the outer air from a motor vehicle engine.

Emissions tester: A device for sampling exhaust gases to measure the amount of air contaminants present.

Engine: A device that burns fuel to produce power.

Ethyl: Tetraethyl lead which is added to gasoline to reduce knocking.

Evaporation: The change of a liquid to a gas.

Evaporation control: A system to prevent the escape of gasoline vapors from the fuel tank, pump, or carburetor.

Exhaust emissions: Air contaminants expelled into the outer air from a motor vehicle engine.

Exhaust-gas analyzer: An instrument used to determine the efficiency of the combustion of an engine.

Exhaust manifold: The passageways that carry the exhaust gases from the engine into the exhaust pipe.

Exhaust muffler: A device that quiets the sound of combustion.

Exhaust stroke: The movement of the piston from bottom dead center (BDC) to top dead center (TDC) when the exhaust valve is open.

Fahrenheit (F.): A temperature scale with the freezing point of water at 32°F. and the boiling point of water at 212°F.

Fast idle: A mechanism on the carburetor that holds the throttle slightly open when the engine is cold to prevent stalling.

FEC: Fuel evaporation control (emission control system).

Filter: A device that removes foreign particles.

Flat spot: A time during acceleration when the engine hesitates for a moment before beginning to pull again.

Float bowl: A reservoir in the carburetor for the fuel.

Float circuit: The system in the carburetor that controls the entry and level of fuel in the float bowl.

Float level: A predetermined height of fuel in the carburetor float bowl.

Flooding: A condition when the air-fuel mixture in the engine is too rich for normal combustion.

Four-barrel carburetor: A carburetor with four venturis and four throttle plates.

Four-stroke cycle: The operations of intake, compression, power, and exhaust which make up one complete sequence for one type of internal combustion engine.

Fuel gauge: The device that indicates the amount of fuel in the fuel tank.

Fuel injector: A device that forces fuel into the cylinder or intake manifold.

Fuel jet: A calibrated opening that meters fuel.

Fuel line: The pipe or tube through which fuel travels from the tank to the carburetor.

Fuel nozzle: A tube in the carburetor through which fuel travels from the float bowl into the air stream.

Fuel pump: The device that draws the fuel from the tank and forces it into the carburetor.

Fuel system: The system that produces a combustible mixture and delivers it to the engine.

Fuel tank: A container that serves as storage for the fuel.

Full throttle: The position of the throttle plate when it is wide open.

Gasket: A piece of material placed between two surfaces to provide a seal.

Gasoline: A hydrocarbon obtained from petroleum that is a suitable engine fuel.

Governor: A device that controls engine speed.

Gravity: The attractive force that pulls things to earth and holds them there.

HC: A hydrocarbon, such as gasoline.

Heated-air system: A vacuum or thermostatically controlled air cleaner that supplies the carburetor with warm air (100°F.) during engine warmup.

Heat-control valve: A thermostatically controlled valve that provides heat to the intake manifold during engine warmup.

Heptane: A reference fuel that knocks very easily and is used in the determination of fuel octane ratings.

High-speed circuit: The system in the carburetor that supplies most of the fuel used under average conditions; also called main circuit or part throttle circuit.

High-test gasoline: A term referring to gasoline that has an above average octane rating (around 95 octane or above).

Horsepower: An indication of the engine's ability to do work.

Hydrocarbon: A compound composed of hydrogen and carbon; gasoline is a hydrocarbon.

Hot spot: An area of the intake manifold that is heated by exhaust gases which improves the vaporization of the fuel.

Idle circuit: The system in the carburetor that provides the proper air-fuel mixture at the lowest engine speed.

Idle mixture: The air-fuel mixture supplied to the engine during idle.

Idle-mixture adjustment screw: The device that allows changing of the idle mixture from rich to lean or vice versa.

Idle port: An opening near the throttle plate area for the discharge of the air-fuel mixture into the airstream during idle.

Idle speed: The speed at which the engine runs without load and with the accelerator pedal released.

Ignition distributor: The part of the ignition system that breaks the primary circuit and also delivers the high-voltage current to the proper spark plug at the proper time.

Ignition system: The system that provides the high voltage current which fires the compressed air-fuel mixture in the cylinders.

Intake manifold: The series of passages that conduct the air-fuel mixture from the carburetor to the cylinder heads.

Intake stroke: The movement of the piston from top dead center (TDC) to bottom dead center (BDC) when the intake valve is open.

Iso-octane: A reference fuel that has a great resistance to knocking and is used in the determination of fuel octane ratings.

Jet: A fuel nozzle, calibrated fuel passage, or opening in the carburetor.

Knocking: An engine sound indicating that the air-fuel mixture in the cylinder is burning too rapidly or at the wrong time.

Liquefied petroleum gas: A hydrocarbon suitable as an engine fuel obtained by compressing volatile petroleum gases into a liquid form.

Low-speed circuit: The system in the carburetor that supplies the air-fuel mixture for the speed range from just above idle to the point when the main circuit becomes operational.

LPG: Liquefied petroleum gas.

Main fuel nozzle: The opening in the center of the venturi area that supplies all the fuel for main circuit operation.

Manifold: Intake or exhaust manifolds; passageways for the air-fuel mixture and products of combustion.

Manifold heat control valve: A device that is thermostatically controlled to direct exhaust gases through passageways in the intake manifold to supply heat to improve the vaporization of the fuel.

Manifold vacuum: The reduced pressure produced in the manifold by the action of the piston moving down on the intake stroke.

Manometer: A device for measuring the difference in pressure; consists of a "U" shaped tube partially filled with a liquid.

Mechanical octane: A term to designate the engine design features that govern the octane requirements of an engine.

Metering rod: A movable tapered rod used to vary the opening of the carburetor main jet.

Methanol or wood alcohol: A poisonous alcohol made synthetically or from the distillation of wood.

Missing: The failure of the air-fuel mixture to burn in one or more cylinders.

Muffler: A chamber in the exhaust system used to quiet the sound of combustion.

NO_x: Oxides of nitrogen.

Nozzle: An opening or jet through which fuel passes when it is discharged into the airstream.

Octane rating: The measurement of the anti-knock quality of an engine fuel.

Orifice: A small opening, or hole, leading into a cavity.

Oscilloscope: An electrical testing device which shows a pattern of the ignition action on a viewing screen.

Otto cycle: The four operations of intake, compression, power, and exhaust; named after the inventor of the four-stroke cycle engine, Nikolaus Otto.

PCV: Positive crankcase ventilation.

Petrol: The European name for gasoline.

Petroleum: Crude oil from which gasoline, lubricating oil, and other products are refined.

Photochemical reactions: Chemical reactions brought about by the absorption of light.

Ping: A metallic rattling sound produced by the engine during heavy acceleration and caused by detonation.

Piston: The movable part of the engine that receives the force produced by the combustion of the air-fuel mixture.

Pollutant: Any substance from crankcase vapors, engine exhausts, or fuel vapors that is expelled into the air.

Port: An opening or jet through which fuel is discharged into the air horn.

Positive crankcase ventilating system: A system that delivers the crankcase vapors, normally expelled into the air, to the intake manifold for reburning.

Power: The rate of doing work.

Power jet: The fuel nozzle that discharges additional fuel into the high-speed circuit when the engine is under a load condition.

Power piston: A vacuum operated piston that provides a richer air-fuel mixture under periods of low manifold vacuum.

Power stroke: The movement of the piston from top dead center (TDC) to bottom dead center (BDC) when the air-fuel mixture is burned and the gases expand.

Preignition: The ignition of the air-fuel mixture in the cylinder by something other than the normal spark at the plug.

Pressure regulator: The device in a liquefied petroleum gas system that reduces the high pressure on the liquid fuel so it may become a vapor.

Prony brake: A type of brake used to determine brake horsepower.

Propane: A type of liquefied petroleum gas.

p.s.i.: Pounds per square inch.

Quadrajet carburetor: A trade name for a four barrel carburetor.

Ram induction: The use of the forward motion of an automobile to take in air through a hood scoop and force it into the carburetor.

Ratio: Relation or proportion of one number to another number.

Resonator: A small additional muffler in the exhaust system that reduces the noise of combustion.

Rocker arm: The part of the fuel pump linkage between the fuel pump diaphragm and the engine camshaft that activates the diaphragm.

r.p.m.: Revolutions per minute.

Screen: A fine mesh wire that prevents the passage of dirt and foreign matter.

Sidedraft carburetor: A carburetor with the venturi in a horizontal position.

Smog: A term coined from smoke and fog to describe a visible type of air pollution.

Spring: An elastic device that yields under stress or pressure and returns to its original position when the stress or pressure is removed.

Stroke: The distance the piston moves from top dead center (TDC) to bottom dead center (BDC) or vice versa.

Supercharger: A device that pressurizes the air-fuel mixture to increase the power output of an engine.

Tachometer: A device for measuring engine speed or r.p.m.

Tank unit: The transmitting device of the fuel indicating system that is installed in the fuel tank.

TDC: Top dead center.

Teflon: A plastic coating with excellent self-lubricating properties.

Tetraethyl lead: A chemical which increases the octane rating of an engine fuel and reduces its tendency to knock.

Thermal efficiency: The relationship between the actual power developed and the potential power in a fuel.

Thermal reactor: A high temperature chamber in the exhaust system where exhaust gases react with additional air to reduce air contaminates.

Thermostat: A temperature sensitive device used to control another device.

Throttle cracker: The linkage from the starter to the carburetor that opens the throttle slightly during cranking.

Throttle return check: A device on the carburetor that prevents the throttle from closing too rapidly.

Throttle valve: A round disc mounted on a shaft in the carburetor that controls the amount of air-fuel mixture reaching the cylinders.

Top dead center: The uppermost point of piston travel.

Torque: Turning effort, usually measured in pound-feet.

Torque wrench: A device that indicates the amount of turning effort being applied to a nut or bolt.

Troubleshooting: The process of diagnosing a problem by observations and tests.

Tuned intake or exhaust system: A system designed to take advantage of the natural frequency of a column of gas to increase the efficiency of an engine.

Tuneup: A process of bringing the engine operation back to original specifications.

Turbocharger: A device which utilizes exhaust pressure to drive a supercharger.

Turbulence: The rapid swirling action imparted to the air-fuel mixture in the manifold or cylinder.

Two-barrel carburetor: A carburetor with two venturis.

Two-stroke cycle: An engine that produces a power impulse per cylinder per revolution.

Unbalanced carburetor: A carburetor which has the float bowl vented to the open air.

Unloader: The linkage that opens the choke when full throttle is applied to lean out a flooded engine.

Updraft carburetor: A carburetor positioned so that the air travels upward through the venturi on its way to the engine.

Vacuum: A space devoid of air or any other substance; a pressure less than the normal air pressure.

Vacuum gauge: A device that measures decreased air pressure.

Valve: A device that can be opened or closed to control the movement of a liquid or a gas passing from one area to another.

Vapor lock: The restriction or prevention of the movement of fuel in the fuel delivery system due to the vaporization of the gasoline.

Vapor recovery: A system to control the evaporation of fuel vapors from the fuel system.

Vent: An opening from an enclosed chamber through which air can pass.

Venturi: The restriction in the diameter of the air horn of the carburetor.

Volatility: The ease with which a liquid vaporizes.

Volumetric efficiency: The ratio between the amount of air-fuel mixture that is actually drawn into the cylinder and the amount that could be drawn in under ideal conditions.

VVR: Vehicle-vapor recovery system (emission control system).

Work: The changing of the position of a body against an opposing force which is measured in foot-pounds.

Directory

AC Spark Plug Division
General Motors Corp.
Flint, Mich. 48556

American Insurance Association
85 John St.
New York, N.Y. 10038

American Motors Corp.
Customer Relations Dept.
14250 Plymouth Rd.
Detroit, Mich. 48232

American Petroleum Institute
1801 K St. NW.
Washington, D.C. 20006

American Vocational Journal
American Vocational Association, Inc.
1510 H St. NW.
Washington, D.C. 20005

Arnolt Corporation
Warsaw, Ind. 46580

Atlas Supply Co.
Diamond Rd.
Springfield, N.J. 07081

Automotive Electric Association
16223 Meyers Rd.
Detroit, Mich. 48235

Automotive Service Division
Bendix Corp.
1217 South Walnut St.
South Bend, Ind. 46620

Automotive Service Industry Association
230 North Michigan Ave.
Chicago, Ill. 60601

C. E. Niehoff and Co.
4925 Lawrence Ave.
Chicago, Ill. 60630

California Air Resources Board
1025 P St.
Sacramento, Calif. 95814

Carousel Films, Inc.
1501 Broadway
New York, N.Y. 10036

Carter Carburetor Division
ACF Industries, Inc.
2840 North Spring Ave.
St. Louis, Mo. 63107

Chapman and Hall, Ltd.
11 New Fetter Lane
London, England

Chas. A. Bennett Co., Inc.
809 West Detweiller Dr.
Peoria, Ill. 61614

Chek-Chart Corp.
222 West Adams St.
Chicago, Ill. 60606

Chilton Book Co.
401 Walnut St.
Philadelphia, Pa. 19106

Classic Motorbooks
3844 Thomas Ave. South
Minneapolis, Minn. 55410

Cowles Book Co., Inc.
448 Madison Ave.
New York, N.Y. 10022

Creative Visuals
P.O. Box 1911
Big Spring, Texas 79720

Current Affairs Films
527 Madison Ave.
New York, N.Y. 10022

DCA Educational Products, Inc.
4865 Stenton Ave.
Philadelphia, Pa. 19144

Delco-Remy Division
General Motors Corp.
Anderson, Ind. 46011

E. I. Du Pont de Nemours & Co., Inc.
Wilmington, Del. 19898

Ethyl Corp.
100 Park Ave.
New York, N.Y. 10017

Floyd Clymer Publications
222 North Vergil Ave.
Los Angeles, Calif. 90004

Ford Motor Co.
Educational Affairs Dept.
3000 Schaefer Rd.
Dearborn, Mich. 48124

Ford Motor Co.
Industrial Relations, Employee Programs
American Rd.
Dearborn, Mich. 48121

General Motors Corp.
Film Library
General Motors Building
Detroit, Mich. 48202

General Motors Corp.
Public Relations Staff
General Motors Building
Detroit, Mich. 48202

General Motors Technical Center
Educational Relations Section
Warren, Mich. 48090

Glenn Mitchell Manuals, Inc.
4926 Savannah St.
San Diego, Calif. 92110

Go-Power Systems
1880 Embarcadero Rd.
Palo Alto, Calif. 94303

Goodheart-Willcox Co., Inc.
18250 Harwood Ave.
Homewood, Ill. 60430

Gumout Division
Pennsylvania Refining Company
Cleveland, Ohio 44104

Henry Elfrink Automotive
P.O. Box 20367
Los Angeles, Calif. 90006

Holley Inc.
Carburetor Division
11955 East Nine Mile Rd.
Warren, Mich. 48089

Howard W. Sams and Co., Inc.
4300 West 62d St.
Indianapolis, Ind. 46268

Humble Oil and Refining Co.
Regional District Office
Pelham, N.Y. 10803

Hygrade Products Division
Standard Motor Products, Inc.
Long Island City, N.Y. 11101

Industrial Arts and Vocational Education
P.O. Box 1616
Riverside, N.J. 08075

John Deere
Service Publications
John Dear Rd.
Moline, Ill. 61265

McGraw-Hill Book Co.
330 West 42d St.
New York, N.Y. 10036

McKnight and McKnight Publishing Co.
Bloomington, Ill. 61701

Modern Learning Aids Division
Ward's National Science Establishment, Inc.
P.O. Box 302
Rochester, N.Y. 14603

Motor Book Department
Hearst Magazines
250 West 55th St.
New York, N.Y. 10019

National Audiovisual Center
Washington, D.C. 20409

New York State Department of
Environmental Conservation
Division of Air Resources
50 Wolf Rd.
Albany, N.Y. 12201

New York State Department of Labor
Division of Employment
State Office Campus
Albany, N.Y. 12226

New York State Petroleum Council
757 Third Ave.
New York, N.Y. 10017

Pennsylvania Refining Co.
Gumout Division
Cleveland, Ohio 44104

Petersen Publishing Co.
8490 Sunset Blvd.
Los Angeles, Calif. 90069

Plymouth Division
Chrysler Corp.
P.O. Box 1658
Detroit, Mich. 48231

Robert Bentley Inc.
272 Massachusetts Ave.
Cambridge, Mass. 02139

Rochester Products Division
General Motors Corp.
Rochester, N.Y. 14603

School Shop
Prakken Publications
416 Longshore Dr.
Ann Arbor, Mich. 48107

Science Research Associates, Inc.
259 East Erie St.
Chicago, Ill. 60611

Scott Education Division
Plastic Coating Corp.
Holyoke, Mass. 01040

Shell Film Library
450 North Meridian St.
Indianapolis, Ind. 46204

Speed and Sports Publishers, Ltd.
Acorn House
Victoria Rd.
London, England

State University of New York at Albany
Film Service
1400 Washington Ave.
Albany, N.Y. 12203

Sterling Educational Films
241 East 34th St.
New York, N.Y. 10016

Sun Electric Corp.
6323 Avondale Ave.
Chicago, Ill. 60631

United Motor Service
3044 West Grand Blvd.
Detroit, Mich. 48202

Universal Education and Visual Arts
221 Park Ave., South
New York, N.Y. 10003

U.S. Department of the Interior
Bureau of Mines
4800 Forbes Ave.
Pittsburgh, Pa. 15213

U.S. Department of Labor
Occupational, Safety, and Health Adm.
Washington, D.C. 20210

U.S. Government Printing Office
Superintendent of Documents
Washington, D.C. 20402

Vista Productions
371 Fifth St.
San Francisco, Calif. 94107

Visual Products Division, 3M Co.
3M Center
St. Paul, Minn. 55101

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Carburetor idle adjustment. Modern Learning Aids. 4 min. color. Purchase - Modern Learning Aids.

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Fuel pump. Sterling. 2 1/2 min. Purchase - Sterling Educational Films.

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DRILL SIZES

Letter Sizes	Drill Diam. Inches	Wire Gage Sizes	Drill Diam. Inches	Wire Gage Sizes	Drill Diam. Inches	Wire Gage Sizes	Drill Diam. Inches
Z	0.413	1	0.2280	28	0.1405	55	0.0520
Y	0.404	2	0.2210	29	0.1360	56	0.0465
X	0.397	3	0.2130	30	0.1285	57	0.0430
W	0.386	4	0.2090	31	0.1200	58	0.0420
V	0.377	5	0.2055	32	0.1160	59	0.0410
U	0.368	6	0.2040	33	0.1130	60	0.0400
T	0.358	7	0.2010	34	0.1110	61	0.0390
S	0.348	8	0.1990	35	0.1100	62	0.0380
R	0.339	9	0.1960	36	0.1065	63	0.3070
Q	0.332	10	0.1935	37	0.1040	64	0.0360
P	0.323	11	0.1910	38	0.1015	65	0.0350
O	0.316	12	0.1890	39	0.0995	66	0.0330
N	0.302	13	0.1850	40	0.0980	67	0.0320
M	0.295	14	0.1820	41	0.0960	68	0.0310
L	0.290	15	0.1800	42	0.0935	69	0.0292
K	0.281	16	0.1770	43	0.0890	70	0.0280
J	0.277	17	0.1730	44	0.0860	71	0.0260
I	0.272	18	0.1695	45	0.0820	72	0.0250
H	0.266	19	0.1660	46	0.0810	73	0.0240
G	0.261	20	0.1610	47	0.0785	74	0.0225
F	0.257	21	0.1590	48	0.0760	75	0.0210
E	0.250	22	0.1570	49	0.0730	76	0.0200
D	0.246	23	0.1540	50	0.0700	77	0.0180
C	0.242	24	0.1520	51	0.0670	78	0.0160
B	0.238	25	0.1495	52	0.0635	79	0.0145
A	0.234	26	0.1470	53	0.0595	80	0.0135
..	.....	27	0.1440	54	0.0550	..	.....